Grand Canyon National Park
Fire Effects Monitoring Program Annual Report
2000 Calendar Year

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February 22, 2001

Executive Summary

This Fire Effects Monitoring Program Annual Report summarizes the Fire Effects Monitoring Program activities from January 1, 2000 to December 31, 2000. The following report justifies the existing plot network, details annual accomplishments, outlines plans for the future, and provides a data summary for information collected to date.

There have been no significant changes to the monitoring protocols in the past year, and none are proposed for the future. The schedule for plot installations in 2001 is the most rigorous ever proposed and is possible only with the full-time commitment of the Fire Effects staff. Such a schedule is necessary to make-up for deficiencies in plot installations over the past seven years. With little prescribed fire activity planned for 2001, this is the perfect opportunity for numerous plot installations.

Data analysis is not significantly different from previous years, except that minimum sample size has been recalculated with a new formula provided in the revised Fire Monitoring Handbook, and only one of the variables of interest meet minimum sample size. This means that we cannot assess 10 of our 11 variables with statistical confidence at this time.

Due to concerns about staffing, housing, and new guidelines, it is recommended that the Regional Fire Ecologist conduct a full program review in the 2002 calendar year to ensure this program is on track.

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INTRODUCTION

During this extraordinary fire season, every available firefighter was needed to aid the national suppression effort. Once the necessary plot re-reads were complete, Fire Effects Crewmembers accepted assignments in helitack, engines, and dispatching across the country, working a total of 2504 hours of overtime. Although we were unable to accomplish all that was planned, we did manage to visit 46 plots for re-reads, post-burn assessments, and installations.

This year's accomplishments are below expectations stated in the 1999 Annual Report, therefore a great expansion of the plot network is planned for the 2001 season.

GOALS

The Fire Effects Monitoring Program exists in order to meet goals and objectives set forth in the General Management Plan, NPS Strategic Plan, and GRCA Strategic Plan. Grand Canyon National Park's General Management Plan (1995) states, "The natural role of fire within park ecosystems will be restored within the constraints specified in the park's Fire Management Plan." It also states, "...surveys will be required for the management of natural resources [including] effects of fire exclusion and prescribed fire on park wildlife and the representative vegetation communities." Long-term goals for preserving park resources are identified in the NPS Strategic Plan (1997) and the Grand Canyon Strategic Plan (1997). The GRCA Fire Effects Monitoring Program operates under Goal Category I: Preserve Park Resources, GRCA Long-term objective Ia1: 10% of targeted disturbed park lands, as of 1997, are restored, and 20% of priority targeted disturbances are contained.

The primary aim of the Fire Effects Monitoring Program is to provide information to fire and resource managers, which allows them to affirm that prescribed fire objectives are being met or to identify and correct deficiencies. Through the Fire Effects Monitoring Program at Grand Canyon National Park, data have been collected on pinyon-juniper woodlands, ponderosa pine associations, and subalpine conifer forests. Other ecosystems such as meadows will soon be part of the Fire Effects Monitoring Program.

Specific goals and objectives regarding the Fire Effects Monitoring Program can be found in the Fire Monitoring Plan, an appendix to the Fire Management Plan. This document is reviewed annually and updated as needed.

STAFFING

The crew visited 46 plots between May 7 and the end of September, 2000.
Grand Canyon hired a GS-9 Fire Effects Specialist in April 2000 to replace the GS-7 subject-to-furlough position. One GS-6 term employee—Fire Effects Crew Leader—managed the crew during 2000 field operations until accepting a new position after pay

period 17. As of February, 2001 the Crew Leader position is still vacant. Five GS-0404-05 seasonals were hired to work on the Fire Effects Crew. Only one is funded from the Fire Effects Base Account; the remainder are funded by Hazard Fuels monies.

Overtime and hazard pay hours are included to indicate that the Fire Effects Crewmembers do not just function as plot monitors at Grand Canyon, but also aid in wildland engine coverage, helibase operations, wildfire suppression, Level 1 fire monitoring, fire reconnaissance, and other activities. Every Fire Effects Crewmember went on at least one out-of-park fire assignment in 2000. See Table 2 for a summary of how crew time was spent during the 2000 calendar year.

TABLE 1. Fire Effects Crew Members for 2000 calendar year.

Monitor	Account #	Starting Date	Ending Date	# Pay Periods	OT Hrs	Hazard Hrs
Tonja Opperman, GS-7/9 (permanent)	Base funded: 251	1/1/00	12/31/00	26	452	215
Kara Leonard, GS-6* (term)	9PP Fuels Overhead funds: 252 12PP Fire FX Base: 252	1/1/00	7/26/00	17	238.9	33
James Roberts, GS-5 (seasonal)	Fuels Overhead funded: 252	4/9/00	11/2/00	15	339.15	190.5
Michelle Farnham, GS-5 (seasonal)	Fuels Overhead funded: 252	4/23/00	11/2/00	14	532	187.5
Jennifer Rowe, GS-5 (seasonal)	Fire FX Base: 252	4/23/00	10/5/00	12	565.9	49
Sharon Klein, GS-5 (seasonal)	Fuels Overhead funded: 252	5/7/00	10/5/00	11	202.55	44.5
Li Brannfors, GS-5 (seasonal)	4.5PPFuels Overhead funds 5PP Project funds	1/10/00 & 11/5/00	3/23/00 & 12/31/00	9.5	173.25	9

*Accepted new position as fire wildlife biologist beginning PP18, 2000.

TABLE 2. Base-hour crew activities by percent and category. Shaded areas are where crewmembers spent majority of base-hour time.

Monitor	FMH-Office	FMH-Field	Wildfire and Helibase Ops.	Rx Fire Ops	FMH Training	Other Training	Fuel Sampling	Air Quality	Teaching and Supervision	Meetings and Conferences
Tonja Opperman, GS-7/9	43	10	15	10	1	1	0	0	4	16
Kara Leonard, GS-6	62	16	4	4	1	4	0	1	0	8
Michelle Farnham, GS-5	40	19	30	3	4	4	0	0	0	0
James Roberts, GS-5	27	44	11	7	0	9	0	0	0	0
Sharon Klein, GS-5	37	22	33	1	0	8	0	0	0	0
Jennifer Rowe, GS-5*	13	30	57	0	0	0	0	0	0	0
Li Brannfors, GS-5	76	2	1	13	6	2	0	0	0	0

*Dispatch and Out-of-Park hours included under "Wildfire and Helibase Ops."

MONITORING TYPES AT GRAND CANYON

Every vegetation type at Grand Canyon National Park where prescribed fire is used, requires the Fire Effects Specialist to develop a document called the FMH-4 Monitoring Type Description sheet. This document provides a physical and biological description, desired future condition, burn prescription, and burn objectives. Grand Canyon's prescribed fire program places great importance on these documents, as they guide every burn plan.

FMH-4 Monitoring Type Description Sheets are completed for PIED, PIPO, PIPN, and PIAB (Appendix H). The PIEN FMH-4 was written in 1993 but needs revision after input from the Natural Resources Branch staff. The GRIN & GRED FMH-4s have not been written but will be in place before plot installation begins in these monitoring types. The JUOS monitoring type is on hold indefinitely, pending funding for further research on pinyon-juniper forests.

GREAT BASIN CONIFER WOODLAND (PIED)

This monitoring type has been discontinued. No new data were collected and no installations are scheduled. If 10-year POST-reads are desired on the PIED plots, the first 10-year post-read would be scheduled for 2002 and continue through 2004. Many plots installed in the PIED monitoring type were installed when the program was still very new in the National Park Service. Written protocols did not exist, there was little crew training, and there was not a year-round staff to maintain data records. Consequently, there are many errors in the data. For example, fuel transects were read at different lengths on different plots, diameters of multiple-stemmed junipers were read in a variety of ways. *Caution should be used when interpreting any of the PIED data now or after a 10-year POST-burn visit.*

SOUTH RIM PONDEROSA PINE (PIPO)

A total of 15 visits were made to PIPO plots during the 2000 field season. Eight plots were burned (including seven burned for the second time) in the Picnic, Entrance, and Quarry prescribed fires.

After the 1998 field season, we determined that only one more plot installation was needed in this monitoring type. A plot was installed in the Horsethief burn unit that was scheduled for ignition in the fall of 1999. However, the Horsethief subunit where the plot was located was not ignited, so this plot has not burned and was re-read in 2000. A plot on the Picnic unit was visited to gather preburn information for a second time (PRE(2)) because it has not burned since it was read in 1992.

Because Grand Canyon National Park's prescribed fire program relies on opportunistic burning to take advantage of all burning opportunities, not all plots are burned in *either* spring or fall as suggested under the standard fire effects monitoring protocols. In order to tease out effects of seasonal burning, we decided, in conjunction with the Regional Fire Ecologist, to install more plots in the South Rim Ponderosa Pine monitoring type. After the plots are burned there may be enough plots in spring to analyze them separately from the plots burned in fall. Before new installs take place, we must determine in which season the burned plots were ignited. Once that is known, we can try to install the new plots in burn units most likely to burn in the season where data are needed. However, there are no guarantees to which season a particular burn unit will be burned. If a unit scheduled to burn in spring of 2001 cannot be burned due to weather or staffing difficulties, that unit is likely to be the first to be ignited in the fall season.

The target for this monitoring type is 34 plots (see Table 3). Twenty-two exist as of December 2000, and 12 more need to be installed. Six plots will be randomized over Grandview, Long Jim III, and Horsethief burn units, to be installed during the 2001 field season. The remaining six plots will be installed in 2002. The Fire Effects Crew will need to remain up-to-date on plans to burn South Rim units so as not to miss an opportunity to collect data.

NOTE: *The above minimum plot calculations are based on the newest version of fmh.exe in which "condition minimum plots" are calculated for post burn data.*

NORTH RIM PONDEROSA PINE (PIPN)

Eight plots were re-read in North Rim Ponderosa Pine, including another PRE read for PIPN11 once it was determined that it had not burned in December, 1999. Plots are located in Walhalla, Outlet, Walla Valley, Northwest III, and Northwest I burn units. Eight plots have burned to date, with the plots on Walla Valley and Northwest I remaining unburned.

Minimum plot calculations suggest a network of 24 plots will accomodate both spring and fall burning (see South Rim Ponderosa Pine, above). The 12 plot installations must be randomized over Walhalla and Walla Valley burn units. Walhalla plot locations are in the northern half of the unit since the southern half has already burned. Walla Valley plot locations have been randomized over the entire unit. During the 2001 field season all of these new installs are scheduled to take place.

NOTE: *Minimum plots have been calculated with the new fmh.exe software. Only 10 plots have been randomized so far, as that was the minimum sample size needed before the recalculation.*

PONDEROSA PINE/WHITE FIR ENCROACHMENT (PIAB)

Nine plots were re-read in the PIAB monitoring type during 2000, including another PRE read of PIAB11, which has yet to burn. Four of the re-reads were POST visits following the Outlet Wildland Fire. One re-read on the Tiyo subunit of the Outlet Prescribed Fire—PIAB 11—burned for the second time within three years, preventing further analysis of this plot with other PIAB plots still on a first-entry burn schedule. No installs were made in this monitoring type as scheduled in 2000. With the possibility of spring and fall burning in this monitoring type, we will add two plots to the network in 2001 to achieve minimum plots needed to evaluate overstory ponderosa pine after both spring and fall burns. These two installs will be randomized over Walla Valley and those suitable areas unaffected by the Outlet Fire of Walhalla, Uncle Jim, Thompson, Range, and Roost burn units.

NOTE: *Minimum plots cannot be recalculated with new fmh.exe software until more YR05 data are collected. Above numbers reflect minimum sample size with preburn data.*

ROCKY MOUNTAIN SUBALPINE CONIFER (PIEN)

Following the Outlet Wildland Fire, five new PIEN plots were installed in areas of high fire intensity to monitor response and recovery of the North Rim Subalpine Conifer forest. Although these plots lack PRE-burn data and therefore can not be compared with any statistical validity to other PIEN plots in the network, they will provide useful standardized data on the effects of the most intense portions of this fire. Two previously installed PIEN plots also burned in the Outlet Fire, including PIEN3, which was re-introduced into the plot network when its data folder was discovered by the park botanist. The two plots in the Boundary burn unit remain unburned and need to be revisited.

With a change in management and need to rewrite burn plans to meet new national standards in 2001, burning in this monitoring type is not expected to proceed as rapidly as previously anticipated. Therefore, PIEN plot installs will take the lowest priority. Six additional plots are planned for installation over the 2001 and 2002 field seasons, at which point 10 total plots will exist—enough to allow an accurate initial minimum plot analysis. These data will give a better target for planning future PIEN installs. Although the forest description is known, the specific objectives for the area remain loosely defined with the exception of fuel load reduction. Consultation with the Natural Resources Branch staff is desired before finalizing the FMH-4 Monitoring Type Description objectives over the coming years.

NORTH RIM MEADOWS (interior and edge) (GRIN & GRED)

Portions of The Basin may be burned in the future. Ten plots will be installed in the 2001 field season—five will be brush transects in the interior (GRassland INterior = GRIN), and five will be "edge" plots to monitor the tree line (GRassland EDge = GRED). Ten additional plots, again split equally between edge and interior, will be installed in 2002. Methods for the "edge" monitoring have not yet been determined and the FMH-4 Monitoring Type Description must be written. A meeting for Fire and Science Center staff to discuss this issue was cancelled due to wildland fire activities in 2000. All of these plots will be installed and read in August so data are as consistent as possible.

MISCELLANEOUS (XXXX)

This is not a monitoring type at all, but is the folder label given to all plots that no longer have a place in Grand Canyon National Park's Fire Effects Monitoring network. They have been removed because they are located on ecotone boundaries that do not fit easily into any of the monitoring types established. This isn't to say that the data are not important, but to include them in the network significantly increases the necessary sample size needed to evaluate primary monitoring variables. Plot stakes remain in the ground, and the plot data remains in the Fire Effects Office to be used if it is ever needed.

MINIMUM PLOT CALCULATIONS AND PLOT INSTALL PRIORITIES

Minimum plot calculations are shown in Table 3 for each monitoring type and each monitoring variable in that type. Following is a justification for minimum plots and installs in each monitoring type.

- For PIED, all plots needed are installed and there are no plans to continue with this monitoring type as it monitored fuel reduction efforts around the village as a result of hand piling and jackpot burning methods.

- The JUOS monitoring type is on hold for the moment as we wait on information from planned research in this monitoring type. Ideally, we were hoping to begin burning these areas in 2001/2002, but it now looks as though that schedule has been pushed back indefinitely.

- For PIPO, because we will burn in the spring and fall without differentiating between different monitoring types, we will install twice as many as the minimum plot calculations indicate, plus four extra plots. In 2001, six plots will be randomly located in the Long Jim III, Horsethief, and/or Grandview units. In 2002 we will install the final six plots in the units that remain unburned, completing the plot network for PIPO. The Long Jim, Grandview, and Horsethief units are the only unburned ponderosa forest areas left on the South Rim. To capture effects of spring burning, plots must be installed the previous year.

- Both meadow/grassland monitoring types (GRIN=grasslands, interior; GRED=grasslands, edge) do not have minimum plot calculations at this time since there are no plots installed. These were formerly called "MEAD" plots. Ten initial plots are needed to monitor the edge of the grassland, and additional initial plots are needed to monitor the interior. These plots must be read/installed in August every year. Grassland plots are a high priority after PIPN installs. We plan on installing *at least* five of each monitoring type in the 2001 field season and the remainder in the 2002 field season for burns planned in October 2002. At this time, we have not identified protocols for these plot installations. It is necessary to consult with the Cultural Resources staff prior to installing any rebar in The Basin grassland.

- In the PIPN monitoring type, overstory ponderosa is, again, the most important monitoring variable. We need 24 plots to account for possible spring and fall burning, but there are currently only 12 plots. Twelve installs are needed to assess fire effects in this monitoring type, and *there is not much area left to be burned on the North Rim that fits this description; therefore, <u>these installs are urgently needed</u>.* Installs are planned on Walhalla and Walla Valley in 2001. It will be important to complete Walhalla installs first since that unit will likely be the first to burn. Although we would like to monitor ponderosa poles with statistical significance, we will monitor ponderosa poles at the highest level possible with 24 plots. To capture fire effects for spring burns, plots must be installed the previous year.

- The PIAB monitoring type already has 22 installed plots, but we must install two more in 2001 to achieve minimum plot calculations for monitoring spring and fall burning. Some spring burns have taken place, but no plots were in these subunits. More plots would be needed to monitor total fuel load and poles, but we will re-evaluate the minimum plots needed for these variables after the 2001 installations. Because there are enough plots already installed in this type for monitoring the primary variable, installing more PIAB plots is the lowest priority for 2001.

- Minimum plot calculations for PIEN are not shown, since there are only four plots. Last year at this time, we had 3 PRE PIEN plots on the shelf that had been installed in 1993-94, numbered 1, 2, and 4. This year, an employee in the Science Center forwarded a folder to us with all the raw data from PIEN plot 3. The data were entered into the database and we now have 4 plots with PRE-burn information in this monitoring type. Two of them burned in the Outlet Wildland Fire, and two remain unburned in the Boundary unit. Five plots were installed as immediate POST plots in this monitoring type in the Outlet Wildland Fire burned area; therefore, we have 7 burned PIEN plots. Six more plots need to be installed for a more precise indication of the number of plots needed. We have planned to install at least 3 of these plots in the 2001 field season.

- The XXXX type does not need to have minimum plot calculations, as it is a repository for plots that currently do not fit in any monitoring type. It is included in Table 3 only for consistency.

TABLE 3. Results of minimum plot calculations by monitoring type and monitoring type variable. *NOTE: Calculations outlined in heavy double lines have been updated using 2/2001 version of fmh.exe to reflect "condition minimum plots". All other calculations are based on PRE data until additional data are available to do post burn calculations.*

	Primary Monitoring Type Variable	Secondary Monitoring Type Variable	Tertiary Monitoring Type Variable
FPIED1D09	Fuels 80%/20 =7	Overstory 80%/20=15 JUOS, 7 PIED	n/a
FPIPO1D09	PIPO Overstory 80%/20=15 (15*2) +4=34 target n=22 Pre n=13@yr05	Total Fuel Load 80%/20=9 n=8 Pre n=8@Post	PIPO Poles 80%/25=55
FJUOS1D06	n/a (n=0)	n/a (n=0)	n/a (n=0)
FPIPN1D09	PIPO Overstory 80%/20=10 (10*2) +4=24 target	Total Fuel Load 80%/20=15	PIPO Poles 80%/25=24
FPIAB1D09	PIPO Overstory 80%/20=10 (10*2) +4=24 target based on Pre calculations n=22 Pre n=2@yr05	Total Fuel Load 80%/20=1 n=22 Pre n=6@Post	ABCO Poles 80%/25=72 n=22 Pre n=7@yr02
BGRIN1D01	n/a (n=0)	n/a (n=0)	n/a (n=0)
FGRED1D01	n/a (n=0)	n/a (n=0)	n/a (n=0)
FPIEN1D10	Total Fuel Load n/a (n=4)	Overstory n/a (n=4)	n/a
FXXXX	n/a (n=12)	n/a (n=12)	n/a (n=12)

GRAND CANYON'S PLOT NETWORK

EXISTING PLOTS AND 2000 ACCOMPLISHMENTS

There are 94 plots currently installed in the network (Table 4), twelve of which are in the FXXXX category and will no longer be monitored on the standard FMH schedule, and two of which are installed on the Shoshone unit and used as "practice" plots. Five plots were installed this year, all on the North Rim. Eighteen visits were made to read post-burn information (Year 1, Year 2, and Year 5 post-burn) and 20 visits were made to Immediate POST-burn plots. Three PRE(2) visits were made to re-read preburn data since plots unexpectedly did not burn and these plots are scheduled to burn in the next two years. This makes for a total of 46 plot visits in 2000.

TABLE 4. Number of plots installed by monitoring type in 2000 and previously.

Monitoring Type Code	Monitoring Type Name	Rim	Number of Plots Installed in 2000	Total Number of Plots Installed
FPIED1D09	Great Basin Conifer Woodland	S	0	17[1]
FJUOS1D06	South Rim Pinyon-juniper Woodland	S	0	0
FPIPO1D09	South Rim Ponderosa Pine Forest	S	0	22
FPIPN1D09	North Rim Ponderosa Pine Forest	N	0	12
FPIAB1D09	North Rim Ponderosa Pine/White Fir Encroachment	N	0	22
BGRIN1D01*	North Rim Meadows--interior	N	0	0[2]
FGRED1D01**	North Rim Meadows--edge	N	0	0[3]
FPIEN1D10	Rocky Mountain Subalpine Conifer Forest	N	5[4]	9
FXXXX	North Rim plots that do not fit in any current monitoring type	N	n/a	12

[1] Two of these 17 plots were installed on the Shoshone Burn Unit after a blowout in pinyon-juniper to monitor post-burn fire effects and to provide "practice" plots for the crew to read every year. One is installed in unburned pinyon-juniper and the other next to it in burned pinyon-juniper.

[2] This is a grass fuel model but is coded as brush in order to allow brush species to be entered in the database if they are encountered during post-burn visits.

[3] We will monitor the edge of the grassland but are not sure what methods we will be using. This is coded as a "forest" model because we anticipate some sort of tree monitoring in this process.

[4] All five of the 2000 installs were installed after the Outlet Wildland Fire, immediately post burn. "PRE" data in the fmh database was crafted from the POST data in order to fool the database and avoid error messages; however, real PRE data do not exist for these plots.

PLOT REMEASUREMENTS FOR 2000 AND BEYOND

Thirty-eight plots were re-measured in 2000 and 44 such visits are planned for 2001 (Table 5). *The GRCA Fire Effects Crew plans to visit more plots in 2001 than in any previous year*, and the workload is expected to grow through 2002 (Table 6). In 2001, 44 plot visits are planned, along with 31 installs for a total of 75 plot visits (Table 7). These installs will take place on the remaining unburned ponderosa forests of the South Rim and on the North Rim. *It is expected that the crew will spike out on the North Rim for 14 weeks in 2001 (July-Sept).*

TABLE 5. Plot re-measurements by plot type for 2000 and 2001.

	Total Plots to Remeasure 2001				**Total Plots Remeasurement 2000**			
Plot Type	G	B	F	Total	G	B	F	Total
YR0X Visits POST Visits	0	0	26 (18 P)	26 (18 P)	0	0	18 (20 P)	18 (20 P)
Total Visits	0		44	44	0	0	38	38

P = Immediate Postburn Remeasurements
R = Remeasured plots to gather Preburn data

TABLE 6. Five-year projected number of plot re-measurements by year

	Number of Plots					
Year	2000	2001	2002	2003**	2004**	2005**
YR0X Visits POST Visits	18 (20 P)	26 (18 P)	49 (34 P)	68 (0 P)	39 (0 P)	23 (0 P)
Total Visits	38	44	83	68**	39**	23**

**These projections assume new plots are not established after 2002. Pinyon-juniper and subalpine conifer forest as well as brush plots may be established during this time but plans are not finalized.

TABLE 7. Projected plot installation.

Plots to be Installed 2001				**Projected Total BY 12/01****			
G	B	F	Total	G	B	F	Total
0	5	26	31	0	5	108	113

**The ability to reach this goal is dependent largely on the nature of the GRCA fire season and resource availability.

POSTBURN PLOT VISIT SUMMARY

Twenty plots burned this year at Grand Canyon: 8 burned in prescription on the South Rim in the Entrance, Picnic, and Quarry burn units; 1 burned in prescription in the Tiyo subunit of the Outlet Prescribed Fire; and 11 burned in the Outlet Wildland Fire (Table 8). The one plot which burned within prescription on the North Rim—PIAB12—had previously burned in the 1997 Tiyo I Prescribed Fire. As this was the second time within three years that PIAB12 had burned, any data subsequently gathered for this plot should no longer be analyzed with other PIAB plots for first-entry burn post-fire effects. Immediate post-burn, year 1, and year 2 data gathered between the Tiyo burns of 1997 and 2000 remain valid for comparison analysis, however.

Table 9 shows how many of the total plots in the network have been visited at post-read intervals. Of the 94 total plots in the network, 60 have immediate post-burn data, and 12 have had immediate post-burn data gathered again, after a second burn. Although 62 plots have actually burned, two immediate post-burn visits were missed in the past, making the total number of visited plots only 60. Under a perfect fire effects monitoring schedule, the Total columns in Tables 8 and 9 would show the same number.

TABLE 8. Number of burned plots.

	Total Plots Burned 2000				**Total Plots Burned to Date**			
Plot Type	G	B	F	Total	G	B	F	Total
Initial Burn Reburn	0	0	12 (8 R)	12 (8 R)	0	0	62 (12 R)	62 (12 R)
Total Burned	0	0	20	20	0	0	74	74

R = Reburns

TABLE 9. Postburn plot summary (visits to date).

	G	**B**	**F**	**Total**
Immediate Postburn*	0	0	60 (12 R)	72
1 Year Postburn	0	0	52	52
2 Year Postburn	0	0	49	49
5 Year Postburn	0	0	29	29
10 Year Postburn	0	0	0	0

*Numbers in parentheses indicate number of second post-burn reads, or POST 02.

WHERE THE PLOTS ARE LOCATED

The plots in the network are randomized across 22 different burn units (Table 10). Maps showing where plots are located in burn units are in Appendix I.

Table 10. Transects/plots classified by burn unit and monitoring type.

	Boundary	Entrance	Hance	Horsethief	Imperial	Lone Tree	Nankoweap	NW I	NW III	Outlet	Picnic	Quarry	Shoshone	Thompson	Tiyo I	Topeka	Village	Vista IV	Walhalla	Walla Valley	Watson IV	Widforss
PIAB									06	08					12			03	13			02
									07	10					22			04	14			11
									25	23								05	15			
																		09	16			
																			17			
																			18			
																			19			
																			20			
PIED		01									02	09				06						
		03									07	10				08						
		04										11				13						
		05														14						
		12														15						
PIEN	02				05		01							08								
	04				06		03															
					07																	
					09																	
PIPN								01											03			
								02											04			
																			07			
																			10			
PIPO		01	15	18		19					04	06				02	08				17	
		07									05	10				03					20	
											11					09					21	
											12					13					22	
																14					24	

* This table reflects plot locations based on actual burn unit boundaries identified in burn plans.

THE LONG-RANGE PROJECT PLAN

See attached Long Range Project Plan (LRPP) in Appendix C. The LRPP will be updated immediately pending policy direction from the national office regarding rewriting burn plans. At this time it is impossible to determine the amount of acreage that can realistically be treated in 2001 without knowing how burn plans may need to be modified. We would like to install 16 plots among the South Rim and North Rim Ponderosa Pine monitoring types since they are most likely going to burn first, and when they are burned, tend to be ignited in large acreages. Planning installations far in advance is necessary because, first, it takes time to install plots over extensive areas, and, second, if an opportunity to install a plot is missed, there may be no unburned areas remaining for future installs in these monitoring types. We have made our best guess at how the LRPP changes will affect plot workloads, and it is reflected in the previous tables of this report.

The shift to landscape-level burning continues, and names for previously delineated small burn units are absorbed into larger units. This can make it difficult to track which plots are in which burn units. It is especially difficult when new burn boundaries are created and combined with poor plot location or burn unit mapping. Now that we have most plots located by GPS, we will be more confident about exactly where plots are located; however, when only portions of large units are burned, *it is necessary to accurately map burn edges in order to know if a plot is burned or not.* In this case, the Fire Effects Specialist or Fire Effects Lead should request this information from the Burn Boss or Prescribed Fire Specialist.

PROGRAM INFORMATION

2000 CHANGES IN PROTOCOL

Calculating Minimum Plots

At Grand Canyon National Park units are burned in both spring and fall for a single monitoring type. For example, South Rim Ponderosa Pine may be burned in spring and fall as conditions warrant. Research from northern Arizona supports burning ponderosa pine in both these seasons. It is not possible to install plots and label them "spring" or "fall". Rather, we will install plots, burn them, and then tease out the information to see differences between spring and fall burning with regard to burn objectives. In order to have enough plots to analyze, we will calculate minimum sample size, double it, then add four "extra" plots to this number for a safety net. This will only be done in monitoring types where we do both spring and fall burning—South Rim Ponderosa Pine (PIPO), North Rim Ponderosa Pine (PIPN), and North Rim Ponderosa Pine with White Fir Encroachment (PIAB). Using this strategy, we should be able to look at the effects of spring and fall burning separately. It is not a perfect solution but will likely serve our needs.

See FMH-4s for details on protocols for each monitoring type (Appendix H).

Randomization over Large Areas

Grand Canyon National Park is moving more burning to landscape scales of 500-3000 acres in one operational period. We have concerns regarding the way plots are distributed over the landscape using the standard FMH protocols. We realize that it is not realistic to install a significant number of plots in each burn unit because this would necessitate hundreds of plots. However, randomizing 10 initial plot locations over the 22,000 acres (as is the case in North Rim Ponderosa Pine) that will burn in five years means we have zero, one, or two plots per burn unit and in 5 years, 100% of the 22,000 acres will be burned and there is nowhere for new installs if they are needed. This is not effective adaptive management. We will try to randomize initial plots in the *first* portion of the area to be burned, and then we will have ample unburned areas to install additional plots in future years. In order to ensure plot information filters back to the Prescribed Fire Manager, *we will randomize these new plots in areas that are scheduled to burn in the next one-three years rather than the next five years* as the FMH protocols suggest.

We would like to consider a different approach with the North Rim Rocky Mountain Subalpine Conifer Forest and the South Rim Pinyon-Juniper Forest in the future. We will randomize ten initial plot locations over the entire area planned for burning in the next 3-5 years. Then, we will install ten plots in the subunit scheduled for burning first. If this subunit already contains some plots, we only need to add enough to ensure ten total plots exist in the subunit. Once the subunit is burned, these 10 plots can provide immediate feedback to the burn boss and Prescribed Fire staff. If results are favorable, we can choose to stop monitoring the "extra" subunit plots and only continue monitoring the original 10 distributed over the landscape.

FUTURE CHANGES IN PROTOCOL

Although not really a change in protocol, but a change in crew management, the GRCA Fire Effects Crew must consider splitting into two smaller crews for portions of the field season in 2001. With many acres planned for ignition in the next few years, and with some of those ignitions taking place in new monitoring types, there is a need for a lot more plot installations. Also, future plot reads on the North Rim need to be completed by September 1 before senescence of herbaceous plants, otherwise they are impossible to identify.

CONTROL PLOTS

Because ponderosa pine is in the spotlight at Grand Canyon National Park, we may opt to use control plots in the near future for monitoring types with ponderosa pine. It will be difficult to install them so that they are not at risk of being burned during a prescribed fire. We are entertaining the idea of re-reading some of the Covington plots that have already been installed on the North and South Rims in ponderosa pine. The park has agreed to protect these plots from fire. Fire Management, Resource Management, and others need to discuss the need for control plots, options for installing them, and the advantages/disadvantages.

EQUIPMENT INFORMATION

Most day-to-day fire effects equipment is in the Fire Effects Office at #1 Shuttle Bus Road. There is a drafting table with items stored underneath, an herbarium desk and storage unit with herbarium supplies, and a large black cabinet with other supplies. Two large black and gray bins are used to haul items in the vehicles during the field season. Items like flagging, clipboards, cruiser vests, camping supplies, and other miscellaneous field items for the fire effects crew are stored in the fire cache, upstairs, in a gray cabinet. Rebar is stored outside the fire effects office in a wooden box painted to match the exterior of the building.

INNOVATIONS

We are fortunate to have a large office where each crewmember has his or her own work space. There are separate computer work areas, an herbarium cabinet and desk with supplies, a drafting table, and storage areas. We have extra storage room up in the fire cache for less frequently used items. The Fire Effects Office was enhanced with an additional computer work station, a dissecting microscope, and a plotter in 2000.

Our "plot board" continues to be invaluable. Crewmembers do an excellent job keeping information updated. It guides daily field and office activities while providing one place to track plot visits and plot data for the season. We photograph it with the digital camera at the end of each season, wipe it clean, and enter each planned plot visit for the following field season.

All of our plots are in individual 3-ring binders filed on a large shelving unit in the office for easy access. The field copy is in the front of each binder and, if that plot needs to be visited, it is taken out each spring and put in a field folder. The field folder is then placed in a designated place in the office with all other field folders for that season. Once a plot is read, the folder is put in a place for "data to be entered" and, once entered, it is moved to a place for "data to be checked". Data then is put back into the 3-ring binder by the Fire Effects Crew Leader.

We have one crew cab truck with a camper shell that has suited our needs for summer plot work. Some years, an additional summer vehicle would be useful if the crew needs to split up between plot monitoring and fire duties.

Housing and work space during time spent on the North Rim was provided by the Trail Crew bunkhouse, which remained unoccupied during the field season.

We created a Plot Status worksheet in Excel97. We use this tool to track plot activities and plan for future installations and workloads. It shows every year (1990-2005) across the top and all plots down the left side. PRE, POST, YR01, YR02, etc. are entered in the appropriate cells and formulas tally annual reads and cumulative plot installs at the bottom. It helps in tracking our accomplishments and filling out tables for the annual report. Additionally, we can add "flags" to some cells if, for example, a POST visit was missed for the plot in a previous year, making plot network inconsistencies immediately recognizable. The worksheet was double-checked with the recently updated plot binders and all summary calculations were verified in 2000.

All plot locations were entered into a GIS database, allowing individual location and travel maps to be produced with ArcView for each plot in the monitoring network. The resulting coverage of all plot locations gives managers another tool in planning future burning activity. Features in ArcView were also used to refine potential plot installation areas and produce randomized locations with an anticipated increased probability of meeting monitoring type description guidelines, thus weeding out more potentially rejected plots.

Our new system for getting plot gear into the field is to have individual plot packs. We purchased six large daypacks and numbered them. Each crewmember is assigned a pack and a portion of the gear for the whole season. A checklist comes with each pack. Crewmembers keep their assigned plot gear and their own personal field gear in their packs. So far, everyone likes this idea and we think it may reduce chances for injury because one person does not have to carry the full load.

In March 1999 an unplanned 15-acre "blowout" occurred in a pinyon-juniper area on the Shoshone prescribed fire unit during ignition. We decided to install a plot in the burned area and another directly adjacent plot in the unburned area to track herbaceous recovery while providing a "practice" area for the Fire Effects Crew. The area is only a few miles from the office off a paved road. Each spring after the crew starts for the season, we all go out to these two plots and complete two reads. This gives the crew a chance to learn the protocols, understand all the forms, and ask questions about the program without the pressure of doing it perfectly the first time. Although we believe RX80 Plot Monitoring Techniques is a good course for fire effects monitors, it is usually not offered before our field season starts. Using our practice plots helps the entire crew understand Grand Canyon's protocols right away and is directly reflected in the data quality of "real" early-season plot reads.

NEED FOR REGIONAL PROGRAM REVIEW

Our relationship with the Science Center continues to strengthen, but there is definitely room for improvement in relations with the botanist, fire wildlife biologist, fire archaeologist, revegetation crew leader, and fire GIS specialist.

There is a need for the Fire Effects Specialist to devote more time to literature review in order to make recommendations on prescribed burning strategies. With the current workload, there is simply not the staff available to free the Fire Effects Specialist position for keeping up with numerous ecology issues, and this has the potential to hinder future progress in the prescribed fire program.

The Fire Effects Specialist recommends job-sharing the new fire ecologist GS-408-9/11 position funded by FIREPRPO with the Science Center staff in order to facilitate communication between fire and resource management. The position can still be housed under Fire Management, but the Natural Resources Branch Chief should have some say in the annual performance standards and sign an annual work plan agreement that is similar to those in place for other Fire/Science Center shared positions. This position sharing truly facilitates an integrated approach to resource management.

In order to bring the adaptive management concept full-circle, it is necessary for the Fire and Science Center staff to meet with the Regional Fire Ecologist to identify trigger points for action. We have specific prescribed fire vegetation objectives, but we have not identified what, exactly, will be done if the objective is not reached.

With the final draft of the Fire Monitoring Handbook ready, some FMH documents at GRCA must be updated. Of the most urgent concern are the FMH-4 objectives which should be rewritten with the new "condition" objective standards, and new calculations in the software to support "condition" objectives with postburn data. There was not time to complete these changes for this report, but they must be completed by December 2001 in order to be ready for the next planning season.

Housing continues to severely hamper the fire program at GRCA. For the 2001 field season, it is unlikely we can hire all four seasonal positions due to bed shortages on the South Rim. This is unfortunate after the lack of plot installs in 2000 due to the busy fire season. Additionally, housing on the North Rim is non-existent for fire effects crewmembers spending up to 14 weeks there every summer. Sleeping in tents and cooking outside during the monsoon season greatly diminishes crew morale. We were lucky to have the trail crew's bunkhouse in 2000 because there wasn't a trail crew, but that is not an option in 2001. There is a possibility for trailers to be rented on the North Rim in order to house crewmembers July-September and provide office space.

Fire Effects crewmembers have always shared in the suppression workload at GRCA, and this has been supported by the Fire Effects Specialist and Prescribed Fire Manager because it allows crewmembers to experience variety in their day-to-day work, learn new skills, observe fires on the landscape, and make extra money in overtime. However, this arrangement is unbalanced because it is taking more away from the overall Fire Effects program than is being provided to the Fire Effects staff. Table 11 shows the difference between the amount of plot installations planned and accomplished for every year since the program was established at GRCA. With the exception of one year, planned plot installations have never been accomplished. With the number of dedicated Fire Effects staff rising in the last few years, it is not reasonable to have so many planned installs cancelled. Weeks of planning are necessary to decide where to install plots, how many to install, and randomizing their locations, only to re-calculate all the information for the following year. In order to remedy this obvious problem, limits on the amount of time Fire Effects crewmembers can spend on suppression projects should be established and enforced. If this doesn't work, Fire Effects staff should no longer be utilized for suppression activities. If data validity and comprehensiveness are to be maintained within the prescribed fire program, the collection, quality control, and archiving of such data need to be given an appropriate level of priority in the fire organization. This issue is further discussed in the Summary of Results section, below.

Table 11. Planned GRCA plot installations vs. actual plot installations by year.

Year	Planned Installs	Actual Installs	Difference
1994	13	4	-9
1995	12	1	-11
1996	9	3	-6
1997	2	5	+3
1998	24	4	-20
1999	21	7	-14
2000	56	5	-51

For all the reasons listed above, a Regional Program Review should be scheduled for 2002. It may be appropriate to meet with both Fire and Resource Management staff during this meeting.

DATA ANALYSIS AND DISCUSSION

INTRODUCTION

This section provides feedback to the prescribed fire staff on how well objectives are met. Some analyses cannot be completed with the current analysis software. Herbaceous data were analyzed in the 1999 Report to provide some preliminary results, and have not been updated as we received no feedback on their usefulness.

The graphical information presented in this report allows resource managers to more accurately determine whether prescribed fire is meeting objectives. Keep in mind that the objectives set in the FMH-4 Monitoring Type Descriptions are based on the best available science, and they can be revised as new information becomes available. All resource managers are invited and encouraged to contribute information that will aid in this process.

STATISTICAL REVIEW

Reporting Variability with SD and CI

It is appropriate to report sample means with a measure of variability to explain how confident we are in our estimates. Otherwise, people tend to interpret the sample means as if they were the true population means. Unfortunately, we can't assume that our sample mean will be the same as the true population mean – that depends on how many samples we take, and how much variability there is in whatever we're measuring. So, we need a way to measure how well our sample mean estimates what's really out there (the true population mean). For this report, we chose to do this using the Standard Deviation of the Mean (SD). SD represents the variability in the actual data we collected. For almost all variables, we do not have the minimum sample size, therefore we chose SD to represent variability. For variables where minimum sample size has been achieved, we used confidence intervals (CI) to express the confidence in our estimate of the true mean.

Interpreting Bar Charts

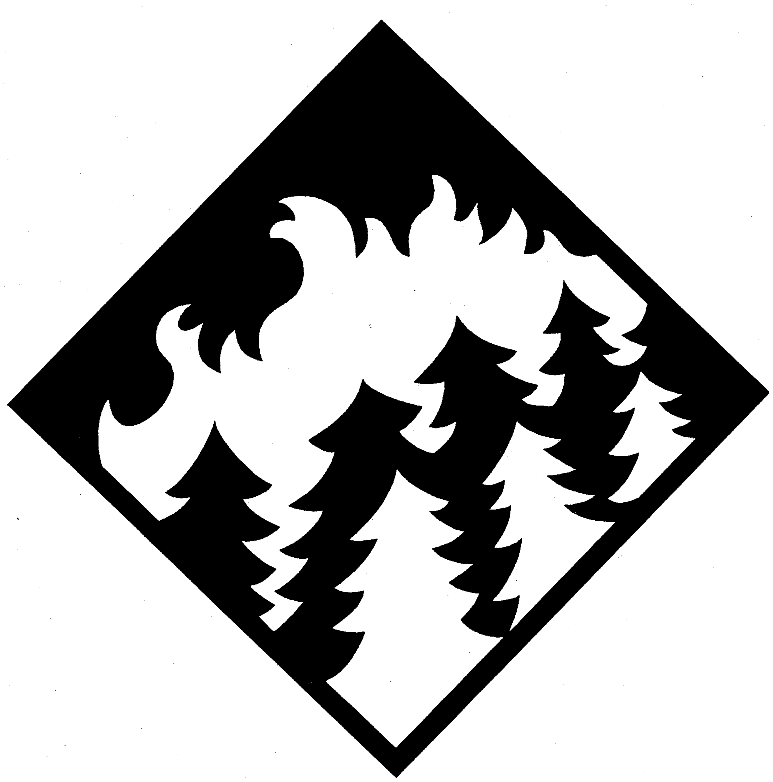
All bar charts in this analysis compare data from the same plots only through time. The preburn reads for which there were no later reads were not included in the analysis. This ensures that sample size (n) is the same for both means (columns), but may be small. The size of the error bars may change over time as the measured data becomes more or less variable. Fuels charts show a break down of fuel size classes with an error bar for the *total* fuel load only. Statistically significant changes cannot be evaluated without more powerful statistical software—remember, averages represent only what was measured in the confines of individual plots if minimum sample size is not met.

Interpreting Scatter plots

The scatter plots show the actual values for each plot visit, the amount of data collected to date, and trends in each plot. A diamond shape that is "moving down" represents a decrease in values over time, a diamond shape "moving up" represents an increase, and a "bull's eye" indicates no change. If there is only one large white diamond, it indicates the plot has not burned.

OUTLET WILDLAND FIRE MONITORING

Five plots (all PIEN) were installed in the Outlet Wildland Fire burned area after the burn. The plot locations were randomized within high-intensity burn areas only. Plots were established to monitor recovery in these areas, although pre-burn data for the plots do not exist. Additionally, 2 PIEN plots and 4 PIAB plots that were previously installed and unburned, were burned in this wildland fire. They will likely not be used in further data analysis for these monitoring types, but may be used in monitoring the effects of the wildland fire. Caution should be used when analyzing preburn data from these plots, because a great deal of time had elapsed between the preburn visit when trees were tagged, and the postburn visit, and there are data inconsistencies. For example, trees tagged as poles in 1993 were overstory trees in 2000. It is expected that all these plots will be monitored on the standard FMH schedule. Preliminary data analysis is provided in Appendix A and will be further explored in future years.



PIPO RESULTS AND DISCUSSION

OVERSTORY DENSITY

Objective 1: Achieve and maintain an overstory *Pinus ponderosa* density (greater than or equal to 16" dbh) of 19-25 trees per acre (47-62 trees/ha) as stated in the Desired Future Condition, and measured at five years post-burn.

Results: Figure 1 shows that there is very little change in large *Pinus ponderosa* overstory tree density across the entire plot network after five years of monitoring. Figure 2 suggests more large trees are needed across the landscape than currently exist, and there is little change in the mean tree density from PRE to Year 5.

Was objective met? Unknown, but trend is favorable. Although the levels of large trees are not at a density previously believed to have existed on this landscape, prescribed fires have not induced significant mortality in this size class of *Pinus ponderosa*. Additional five-year data will be available next year to further assess this variable with greater confidence.

OVERSTORY SCORCH

Objective 2: Limit average crown scorch on overstory *Pinus ponderosa* (greater than or equal to 16" dbh) to 30%, measured immediately post-burn.

Results: At this time we cannot complete analysis for this variable. The database program (fmh.exe) does not allow assessment for scorch on trees of our unique size class. They can be compiled by hand at a future date. Figure 3 shows the data we *can* extract from the database—mean scorch per plot on all live ponderosas greater or equal to 6 inches (15 cm) dbh. This graph indicates only 4 of 19 plots had a mean scorch of greater than 30% after the first entry burn and only 2 of 9 plots had a mean scorch of greater than 30% after the second burn. Since this includes all trees from 6-16 inches (15-40 cm), it is likely that if they are taken out of the analysis, the mean scorch heights will be lower for trees greater than 16" (40 cm) dbh. Figure 4 shows minimum, mean, and maximum scorch heights for the first and second-entry burns.

Was objective met? Unknown, but likely met.

FUEL LOADING

Objective 3: Maintain an average total fuel load of 0.2 to 9.3 tons/acre (0.5 to 23 tons/ha) as stated in the Desired Future Condition, measured immediately post-burn.

Results: Figure 5 shows total fuel load by plot for the entire plot network. Notice that many preburn data points are missing due to faulty data collection methods. At this time, there are 8 plots with comparable preburn and postburn data. Figure 6 is the total mean fuel load for comparable plots, showing that the mean fuel load is just within the Desired Future Condition limit. Most of the fuel reduction was in litter and duff material.

Was objective met? Unknown until minimum sample size is achieved, but it looks as though the trend is favorable.

POLE DENSITY

Objective 4: Reduce *Pinus ponderosa* poles with dbh of 1-6 inches (2.5-15cm) to average 0-200 trees/acre (0-494 trees/ha), measured 2 years post-burn.

Results: Figure 7 shows the plot data across the network; note the high variation in pole densities from 0 to nearly 1800 poles/hectare. Figure 8 shows that mean *Pinus ponderosa* pole densities monitored through Post Year 2 decreased from 430 to 350 trees per hectare, but the error bars are large.

Was objective met? Unknown with such high variability in the data, but trend is favorable.

SNAG DENSITY

Objective: Track snag densities over time.

Results: Figure 9 shows that small snag densities have increased on 5 plots, decreased on 3 plots, and remain unchanged on others from preburn through Post Year 5 monitoring. Values range from 0-80 small snags/ha after 5 years. Large snags show less variability (Figure 10) but the zero values on most plots confound the data, making error bars wide (Figure 11). Figure 11 represents means for the two size classes from preburn through 5 years. Relatively little change has occurred in the larger trees, but snags have doubled in the 6-15.9" size class.

Was objective met? There is no objective for a certain number of snags at this time. Consultation with the Grand Canyon National Park wildlife biologist is needed to define an objective.

<u>SEEDLING DENSITY</u>

Objective: Track seedling densities over time.

Results: <u>Figure 12</u> shows *Pinus ponderosa* seedling densities decreasing on most plots. This is effectively arresting the pole density problems in future decades. Data variation in plot 12 has yet to be explained. Figure 13 illustrates variation in *Quercus gambelii* seedlings due to resprouting after fire. In plots where QUGA did not exist before burning, there is no change, but in plots where QUGA did exist, there are increases.

Was objective met? There is no objective for seedling densities at this time. This information is provided for general knowledge, so that other resource management staff at Grand Canyon know the trends that are occurring.

Figure 1. Live 16" DBH and larger *Pinus ponderosa* Densities, by plot
December 2000

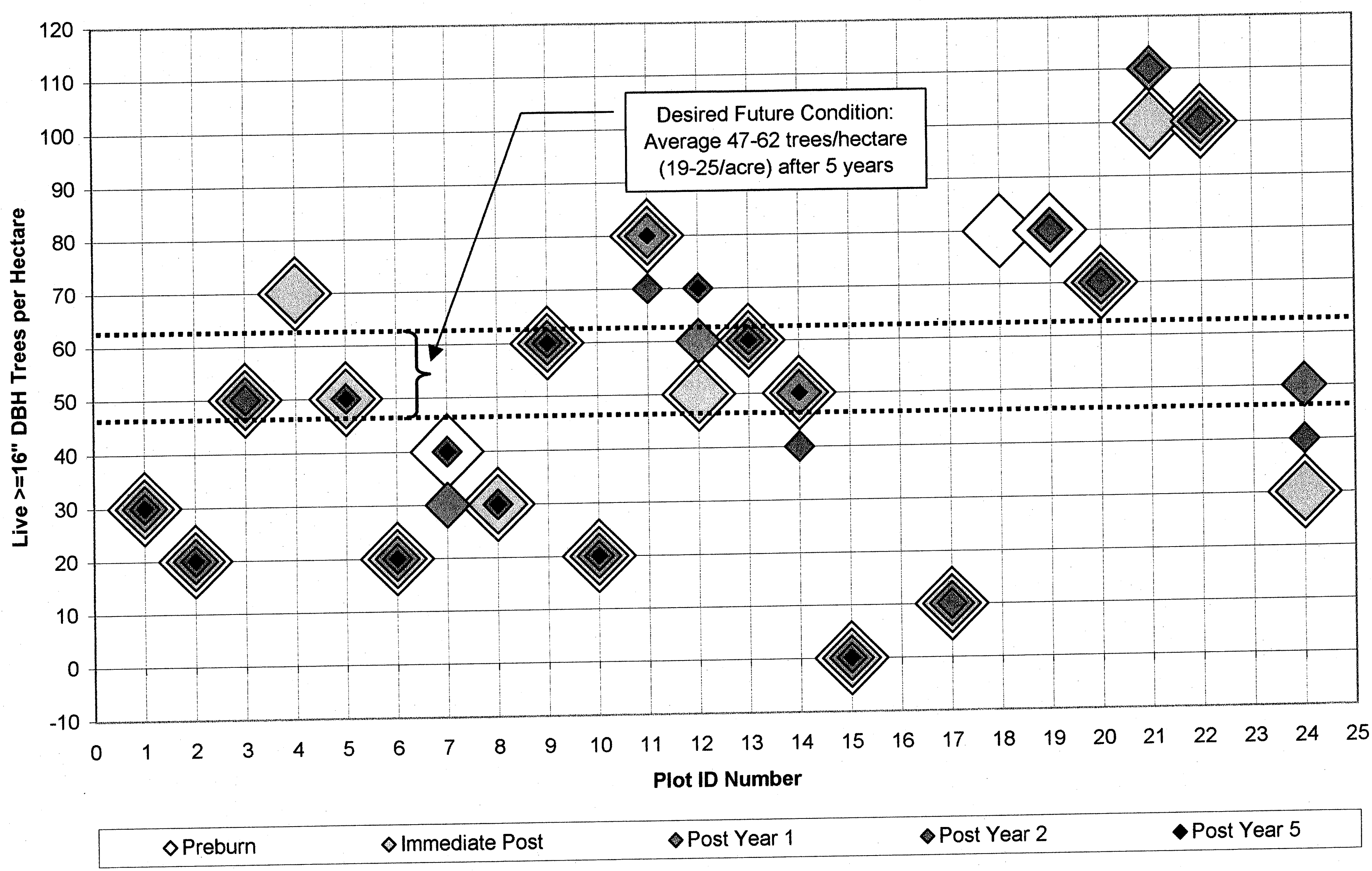


Figure 2. Mean Density of Live 16" DBH and larger *Pinus ponderosa*
December 2000
n = 13 plots, *minimum required plots = 15*

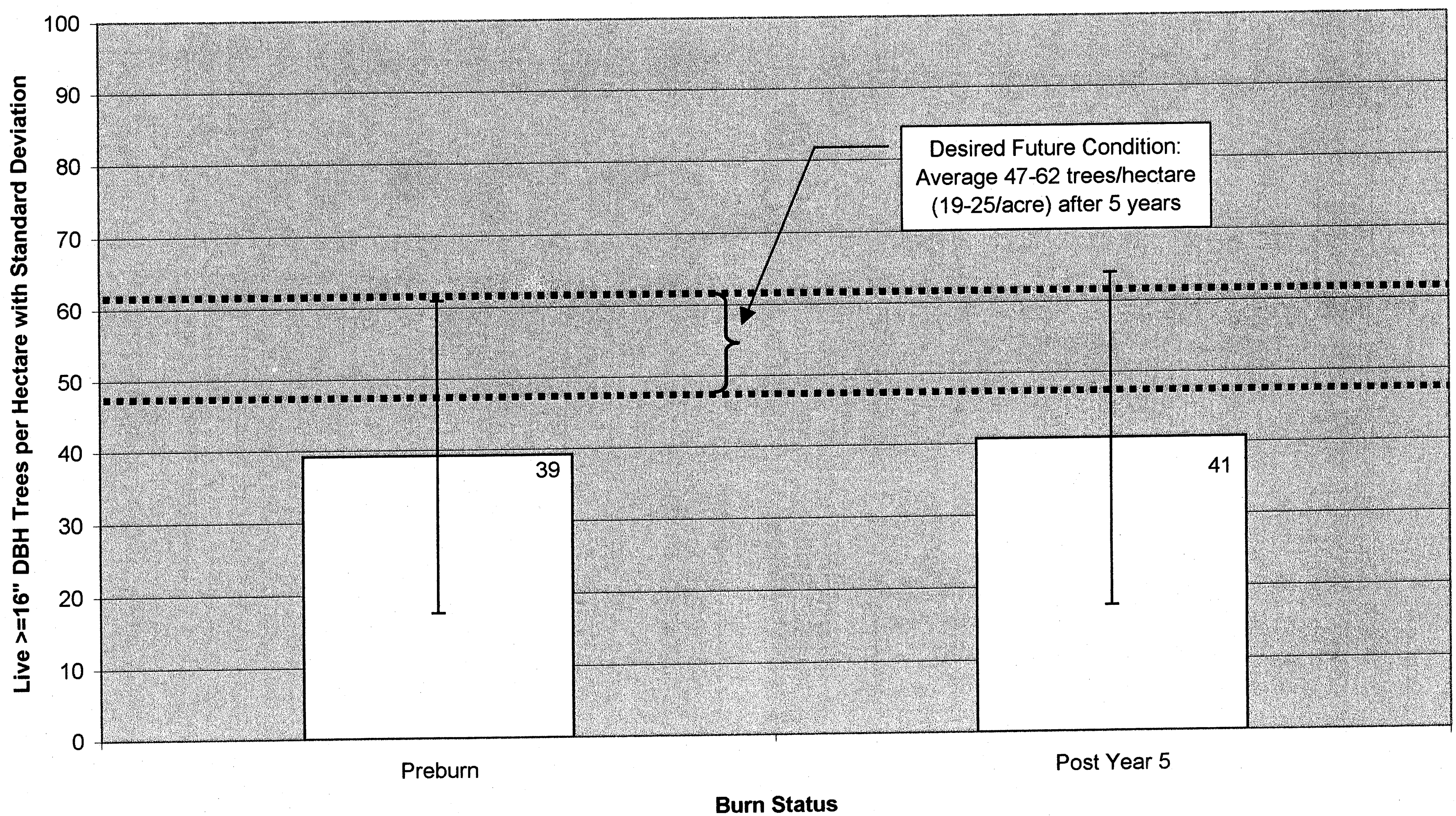


Figure 3. Post-burn Crown Scorch Percent on Live *Pinus Ponderosa* Overstory Trees, by plot
December 2000

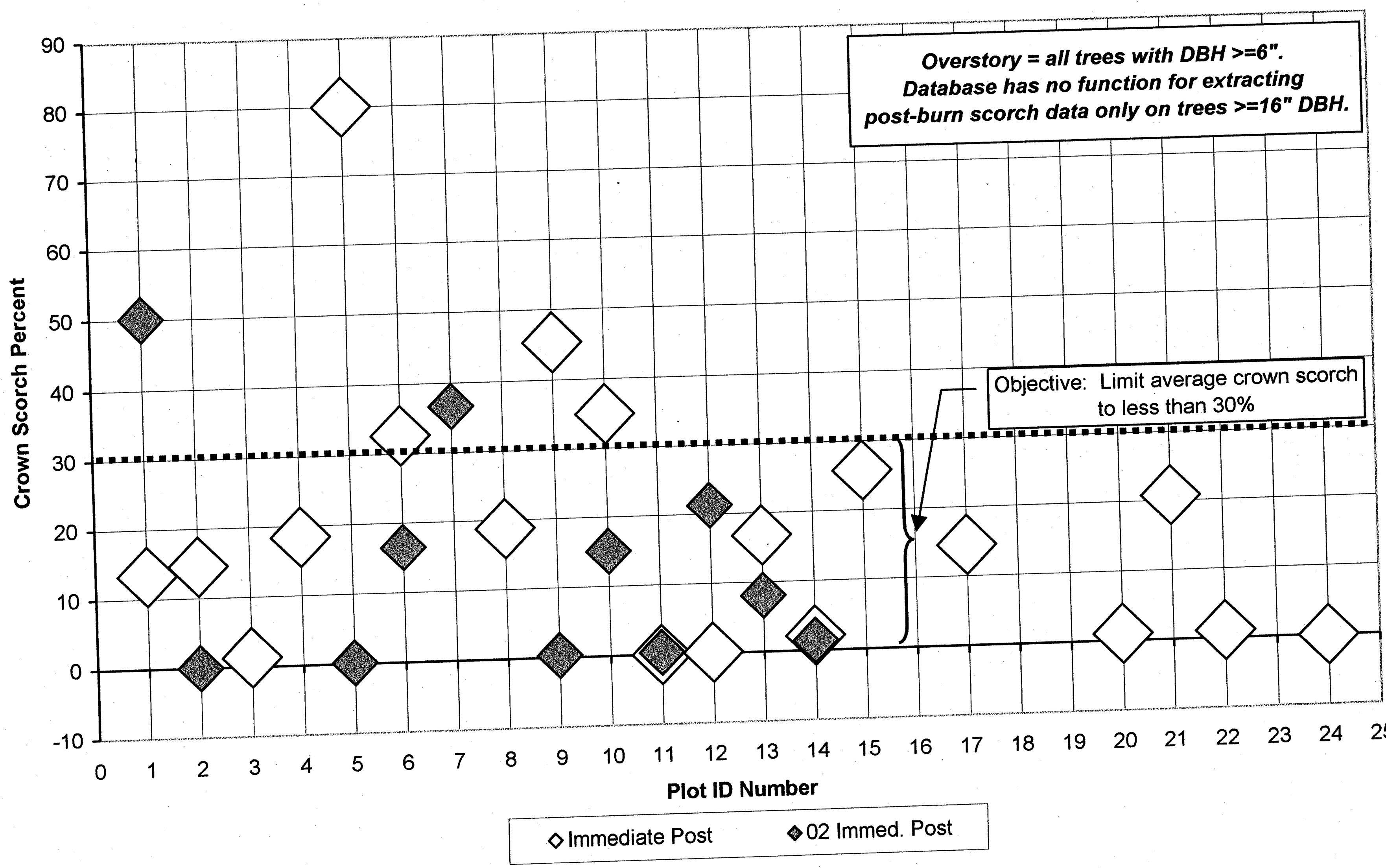


Figure 4. Post-burn Crown Scorch Percent on Live *Pinus ponderosa* Overstory Trees
December 2000

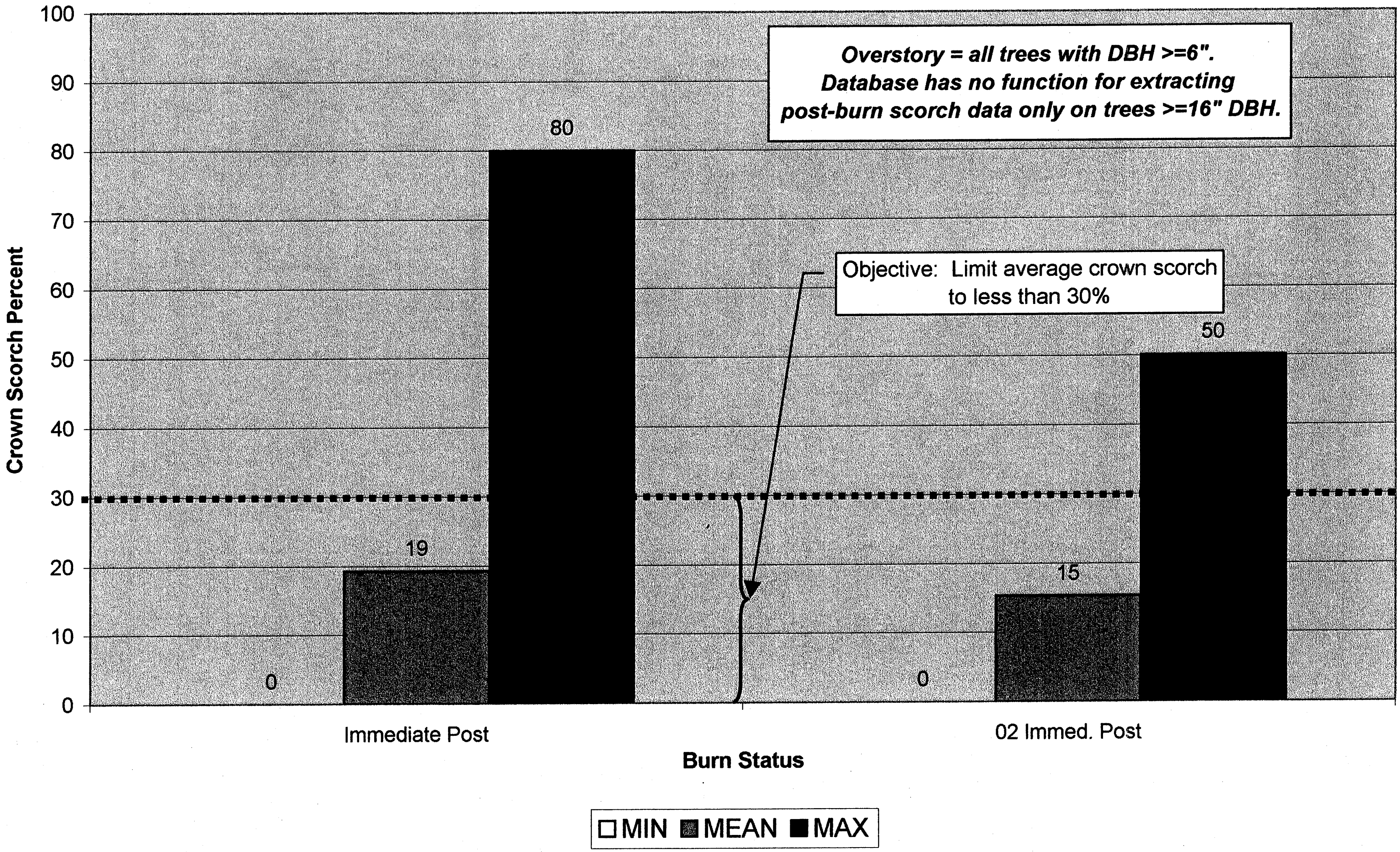


Figure 5. Total Fuel Load by Plot
December 2000
100-foot fuel transects

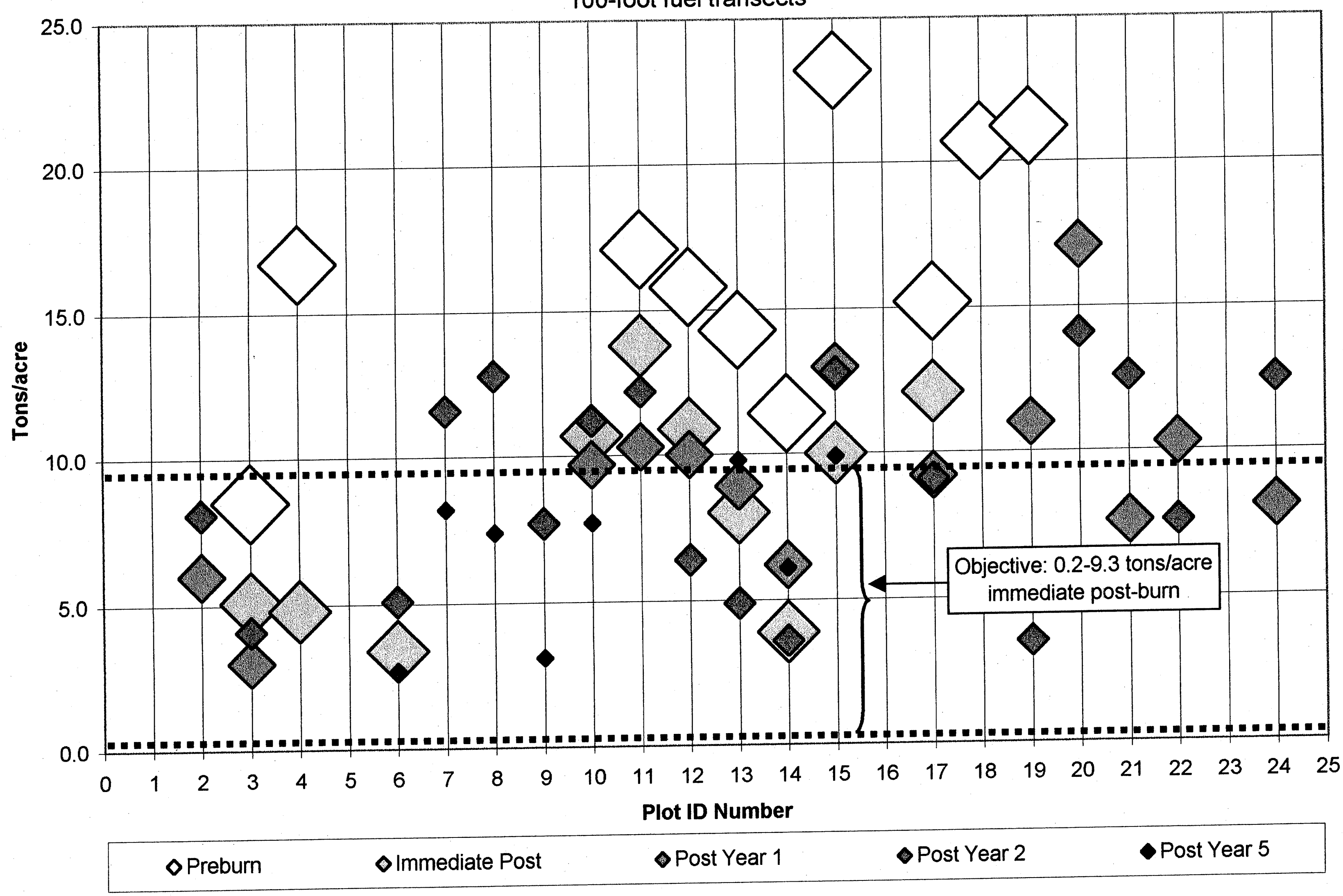


Figure 6. Total Mean Fuel Load
December 2000
100-foot fuel transects
n=8, *minimum required plots = 9*

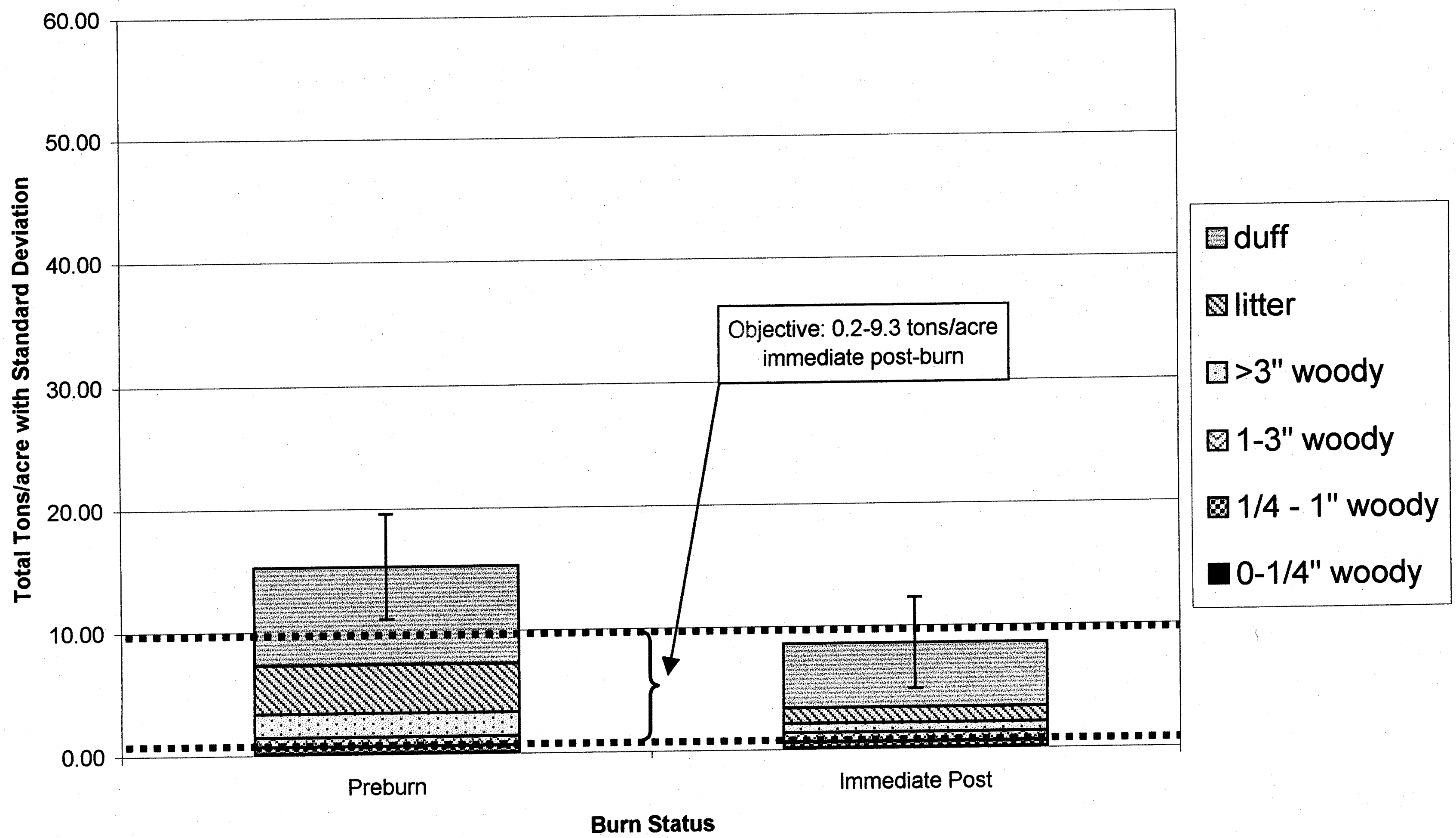


Figure 7. ***Pinus ponderosa*** **Pole Densities, by plot.**
December 2000

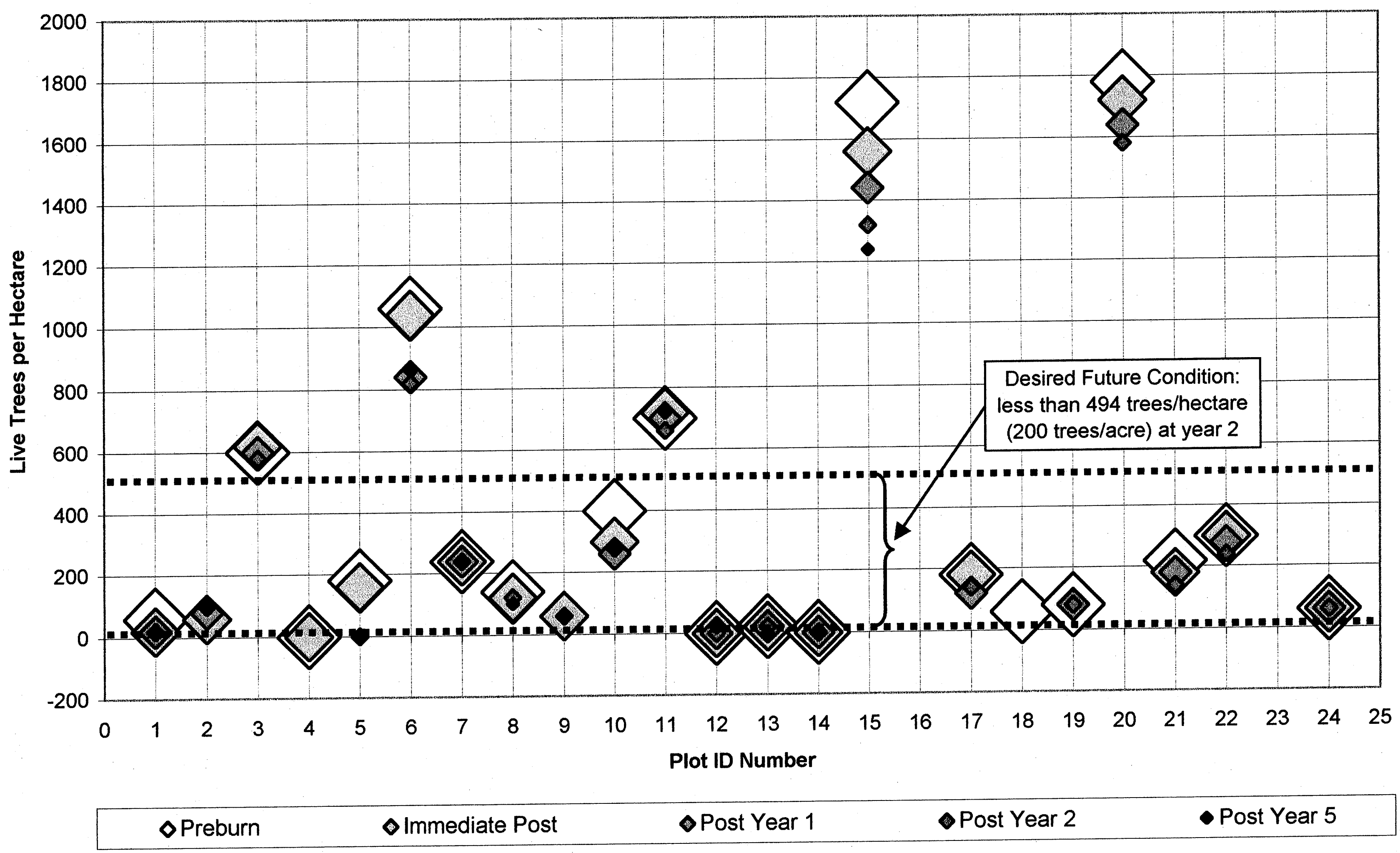


Figure 8. Mean *Pinus ponderosa* Pole Density
December 2000
n = 18 plots, *minimum required plots = 86*

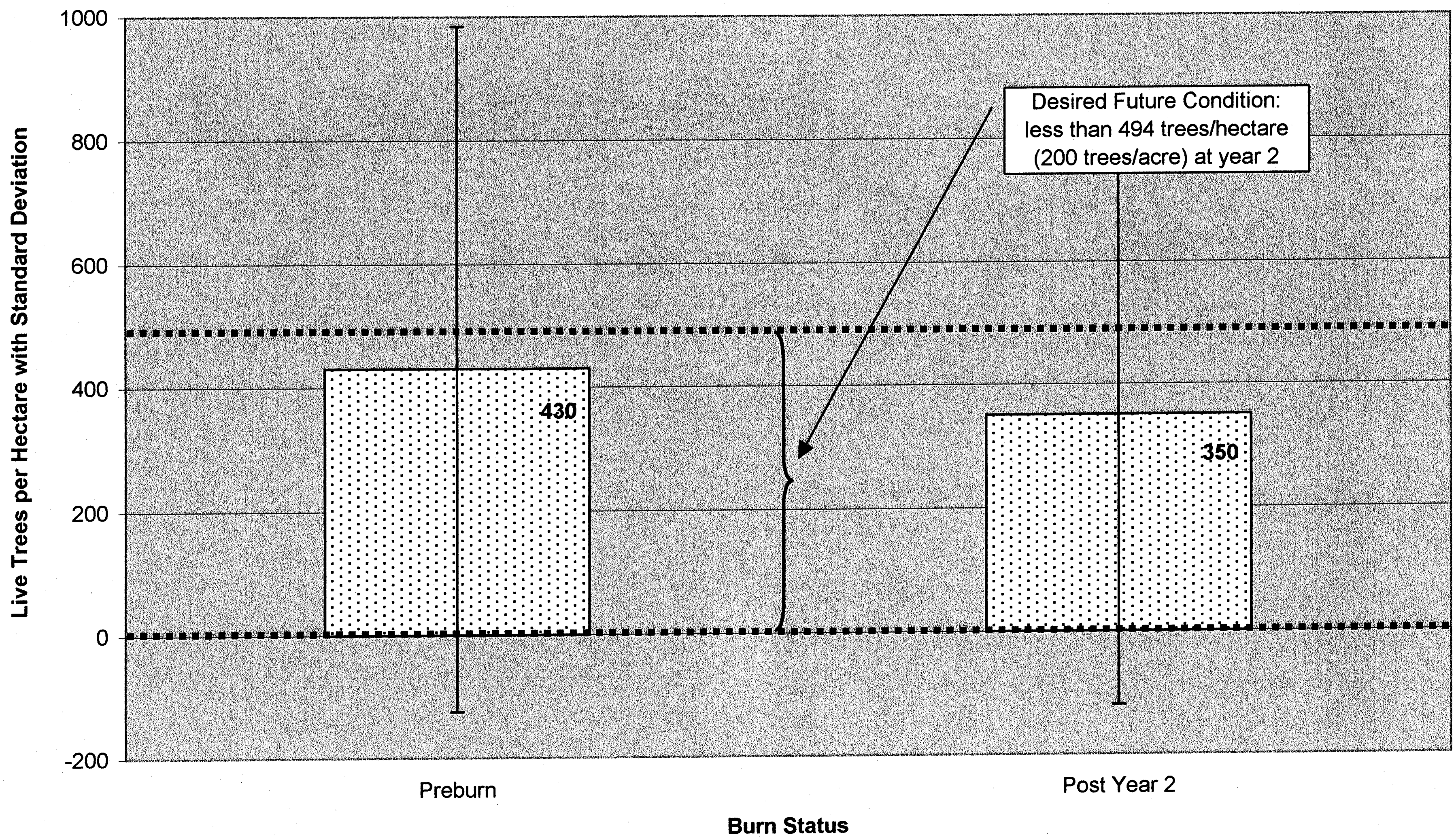


Figure 9. 6 - 15.9" DBH Snag Densities, by plot
December 2000

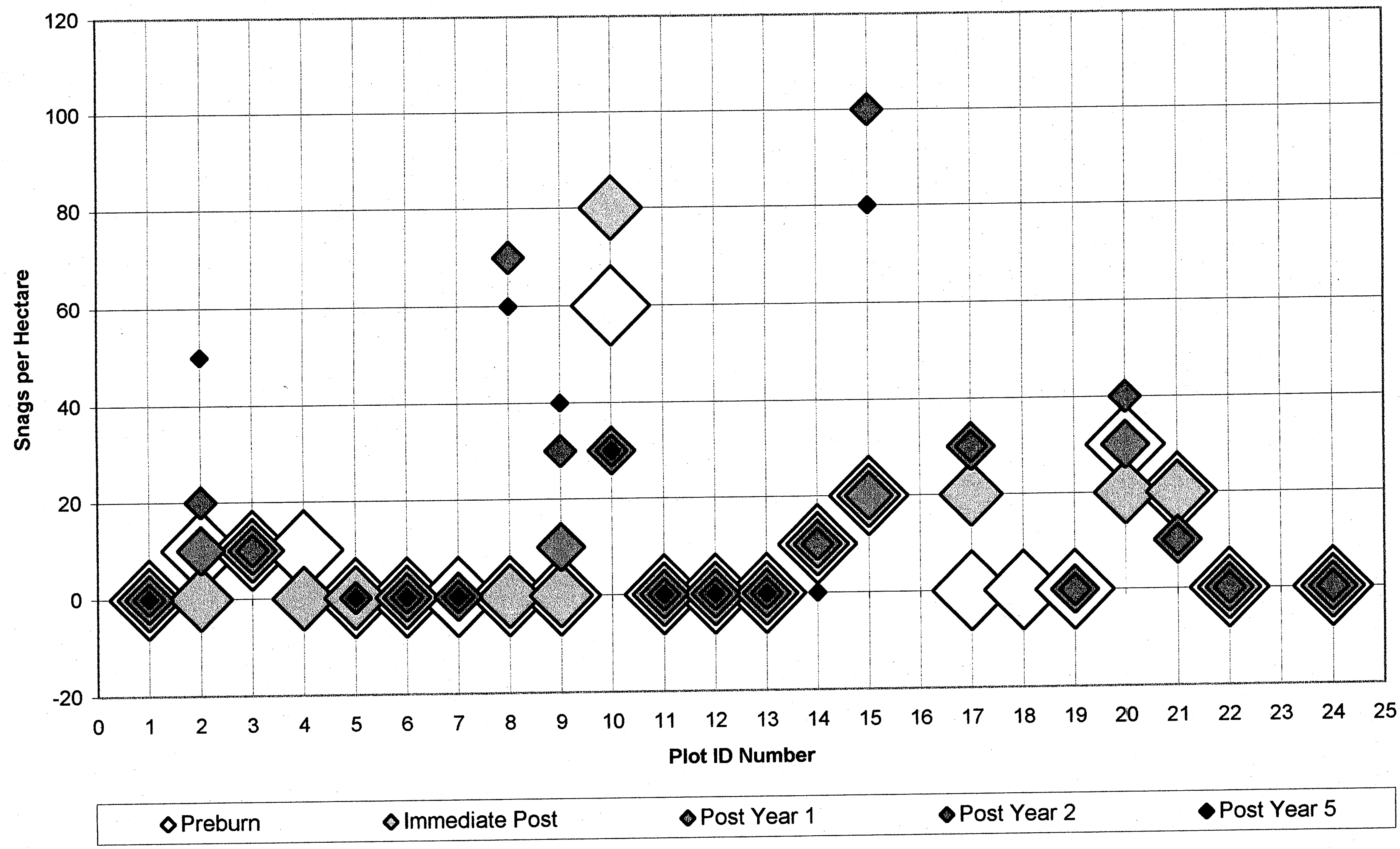


Figure 10. 16" DBH and larger Snag Densities, by plot
December 2000

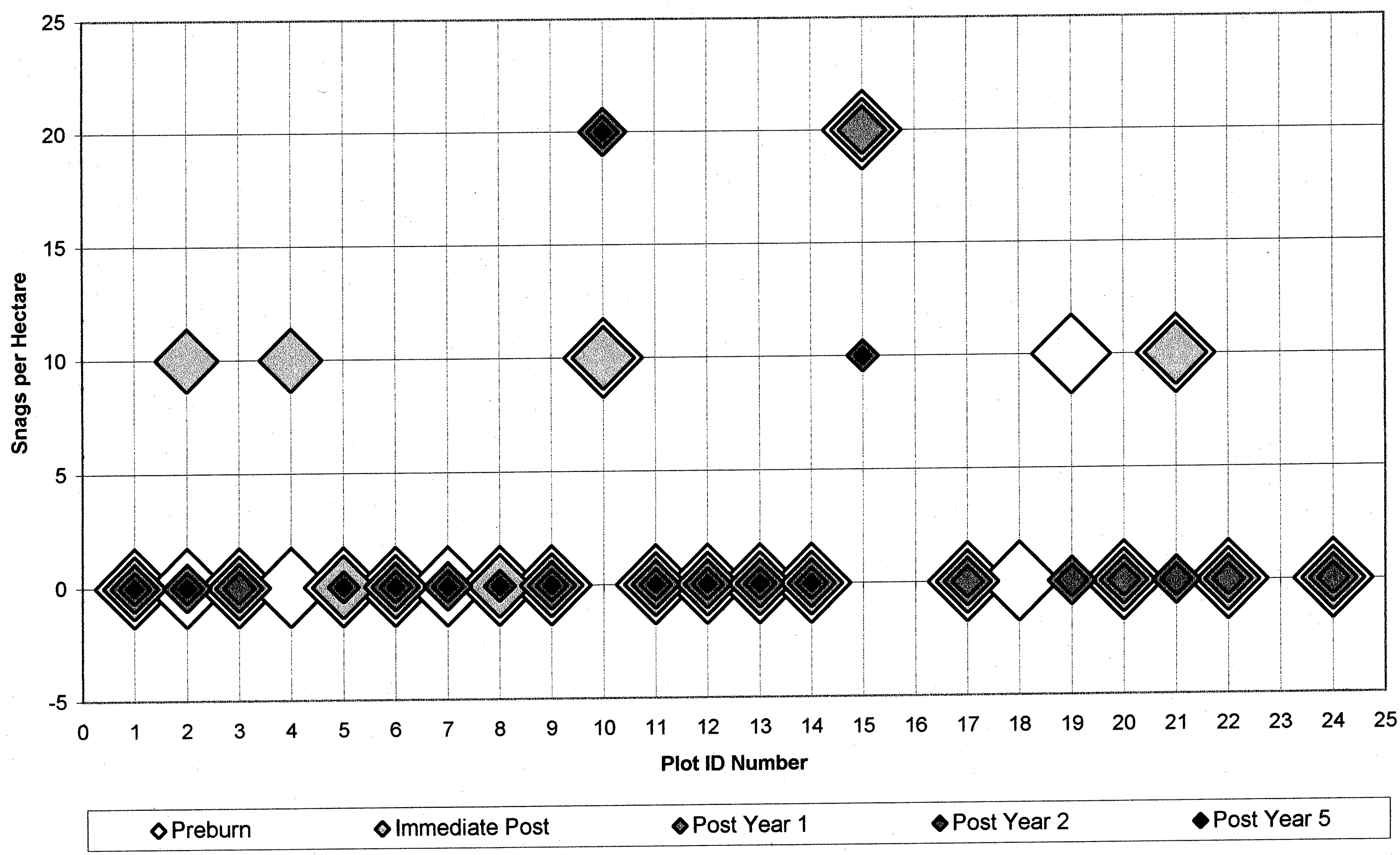


Figure 11. Mean Snag Density, by size class
December 2000
n = 13 plots; *minimum required plots = 310 (>=16"), 94 (6-15.9")*

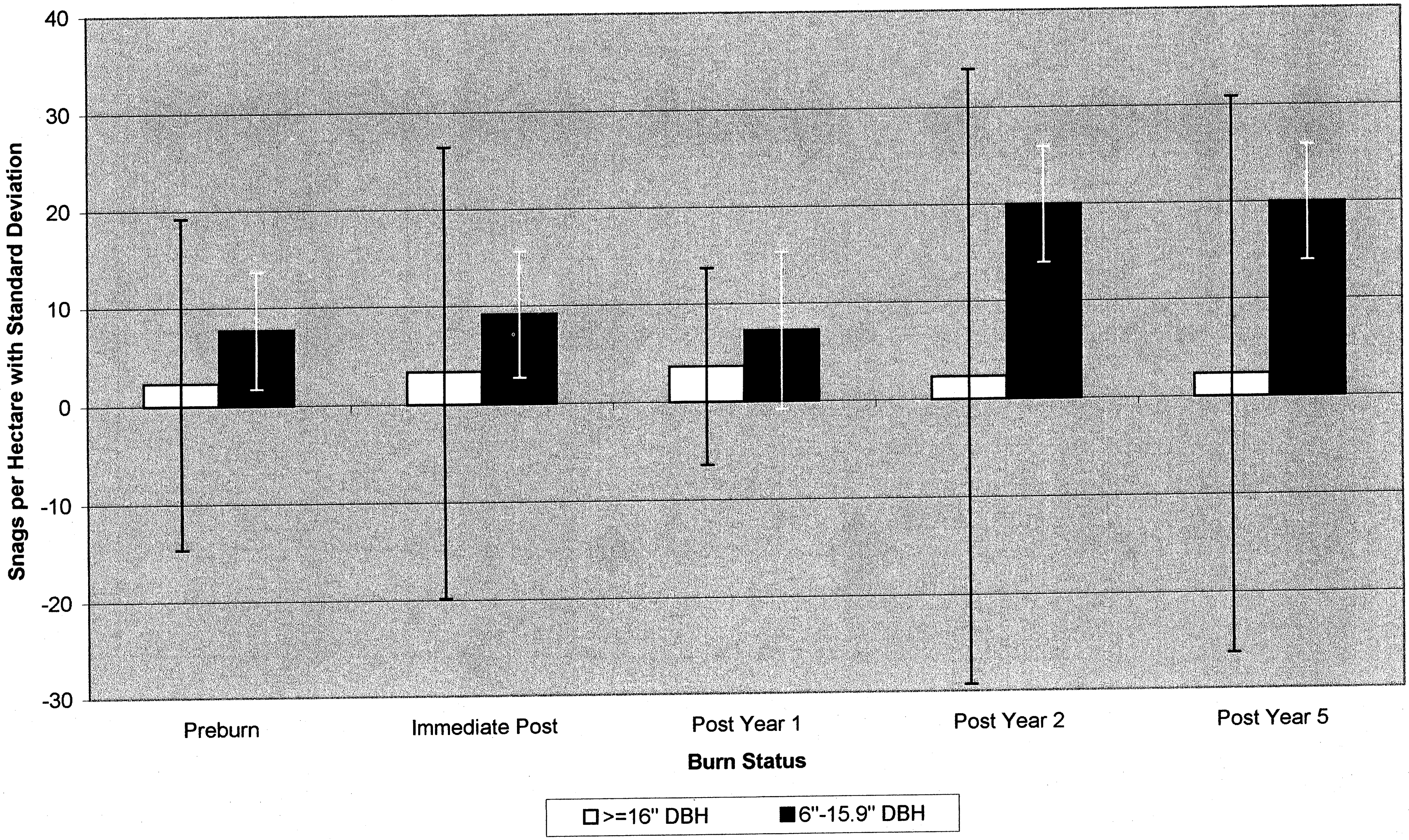


Figure 12. ***Pinus ponderosa*** **Seedling Densities, by plot**
December 2000

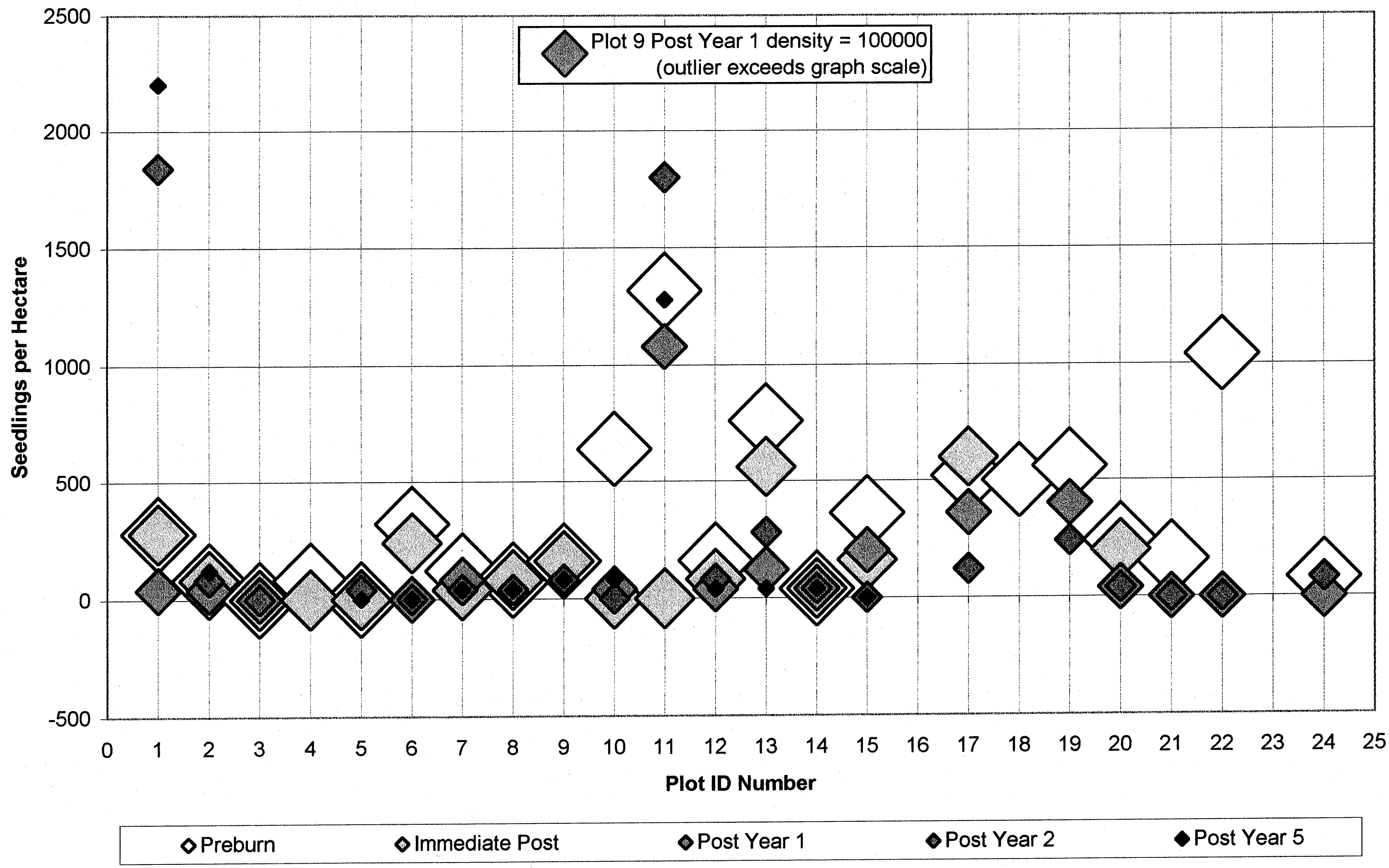
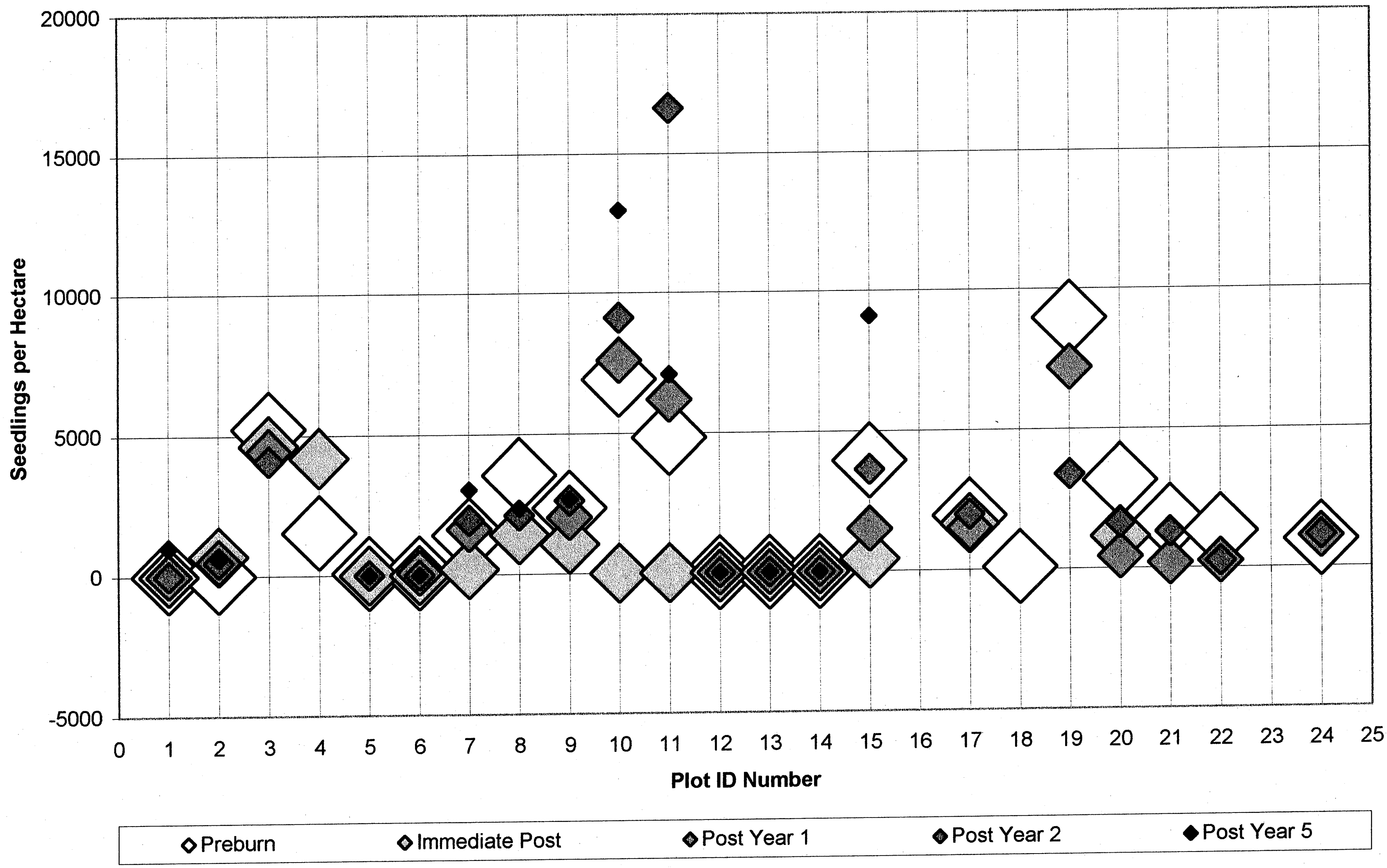


Figure 13. ***Quercus gambelii*** **Seedling Densities, by plot**
December 2000



PIPN RESULTS AND DISCUSSION

<u>OVERSTORY DENSITY</u>

Objective 1: Achieve and maintain an overstory *Pinus ponderosa* density (greater than or equal to 16" dbh) of 40-56 trees per acre (99-136 trees/ha) as stated in the Desired Future Condition, and measured at five years post-burn.

Results: <u>Figure 14</u> illustrates little change in large *Pinus ponderosa* across the entire plot network. There are only 2 plots with 5-year data—both showing a change in density between 2 and 5 years postfire One shows a positive change, and one a negative change. Plots 1 and 2 were both burned in the Northwest III prescribed burn in 1993. There is no bar graph for this variable because there are only 2 plots with 5-year data.

Was objective met? It is unknown at this time, since there are not enough five-year data.

<u>OVERSTORY SCORCH</u>

Objective 2: Limit average crown scorch on overstory *Pinus ponderosa* (greater than or equal to 16" dbh) to 30%, measured immediately post-burn.

Results: At this time we cannot complete analysis for this variable. The database program (fmh.exe) does not allow assessment for scorch on trees of our unique size class. They can be compiled by hand at a future date. <u>Figure 15</u> shows the data we *can* extract from the database—mean scorch per plot on all live ponderosas greater or equal to 6 inches (15 cm) dbh. This graph indicates only 2 of 9 plots had a mean scorch of greater than 30% after the first entry burn. Since this includes all trees from 6-16 inches (15-40 cm), it is likely that if they are taken out of the analysis, the mean scorch heights will be lower for trees greater than 16" (40 cm) dbh. <u>Figure 16</u> shows minimum, mean, and maximum scorch heights for the first-entry burn.

Was objective met? Unknown, but likely met.

<u>FUEL LOADING</u>

Objective 3: Maintain an average total fuel load of 0.2 to 9.3 tons/acre (0.5 to 23 tons/ha) as stated in the Desired Future Condition.

Results: <u>Figure 17</u> shows a lot of change on individual plots, with fuel loads decreasing for the most part. <u>Figure 18</u> shows that duff and litter are decreased the most after the first-entry burn, but error bars are very wide. It is understood that it will likely take more than one treatment to reduce fuel loads adequately. A burn prescription that would reduce fuel load to desirable levels the first time would be too hot for overstory ponderosa pine.

Was objective met? Unknown without minimum sample size achieved, but trend is in the direction desired.

Pole Density

Objective 4: Reduce *Pinus ponderosa* poles with dbh of 1-6 inches (2.5-15cm) to average 0-200 trees/acre (0-494 trees/ha), measured 2 years post-burn.

Results: Figure 19 shows that *Pinus ponderosa* pole trees are generally within the range of Desired Future Conditions, with the exception of plot 5. Figure 20 shows mean densities to be decreasing, although error bars are wide.

Was objective achieved? Unknown. Minimum sample size has not been achieved for this variable. Future randomized plots for this variable could be more like plot 5 and therefore raise the mean density considerably.

Snag Density

Objective: Track snag densities over time.

Results: Figure 21 shows small snag density changes across the plot network. Response to fire ranges from the increase on plot 1 to the decrease on plot 3. Figure 22 illustrates decreases in large snag densities on some plots. Plots 1 and 2 were both burned in the Northwest III prescribed burn in 1993. There is no bar graph because there are only 2 plots with 5-year data.

Was objective met? There is no objective for a certain number of snags at this time. Consultation with the Grand Canyon National Park wildlife biologist is needed to define an objective.

Seedling Density

Objective: Track seedling densities over time.

Results: Figure 23 shows *Abies concolor* seedling densities across the monitoring network. Many plots have zero values, and one plot shows a large increase while another shows a large decrease. Figure 24 shows *Pinus ponderosa* seedlings densities on all plots, most all of which show negative trends where seedlings existed before the fire. Figure 25 shows many zero values for *Populus tremuloides* seedlings, and some slight increases on plots 1 and 2 five years postfire.

Was objective met? There is no objective for seedling densities at this time. This information is provided for general knowledge, so that other resource management staff at Grand Canyon can see the trends that are occurring.

Figure 14. Live 16" DBH and larger *Pinus ponderosa* Densities, by plot
December 2000

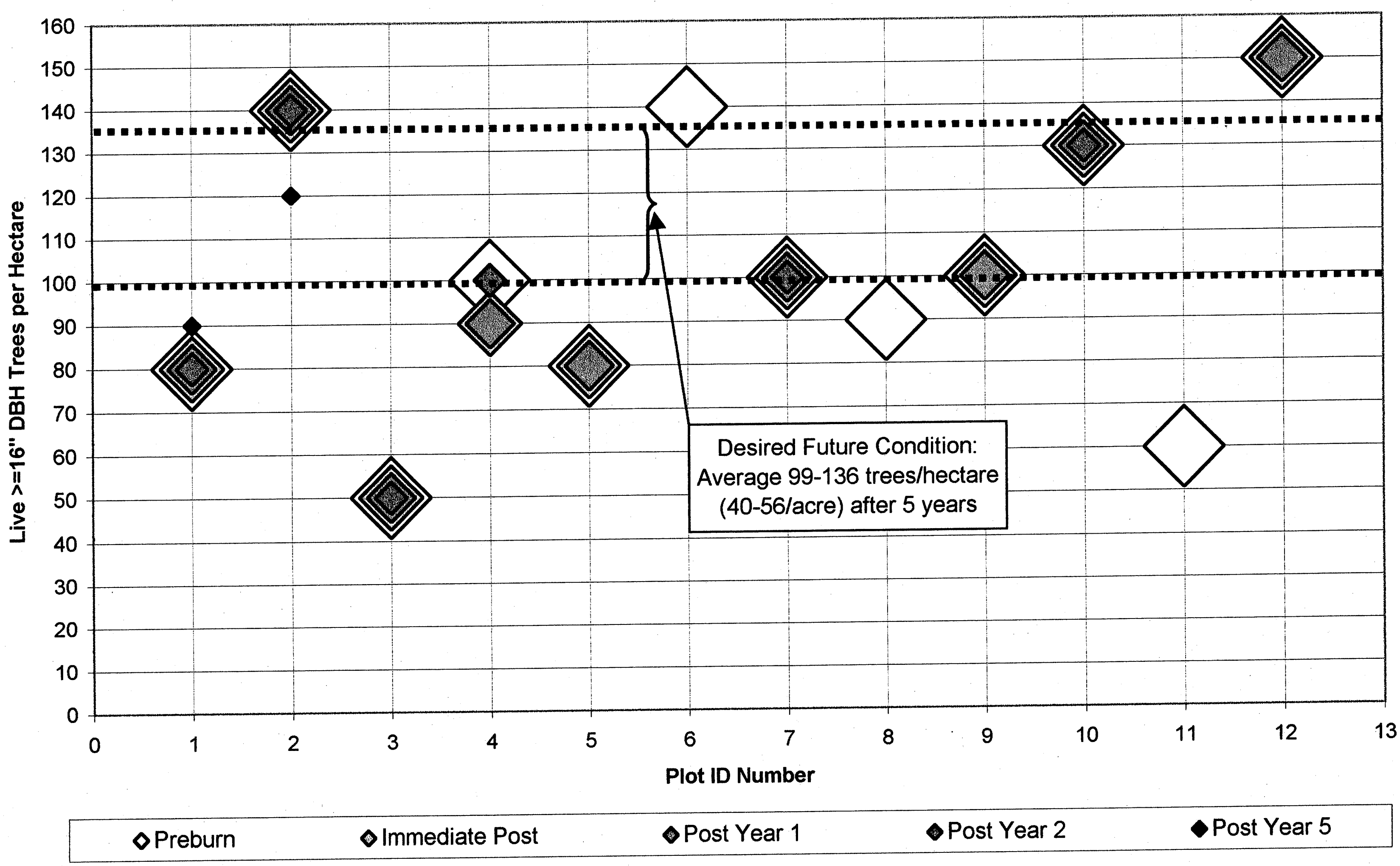


Figure 15. Post-burn Crown Scorch Percent on Live *Pinus Ponderosa* Overstory Trees, by plot
December 2000

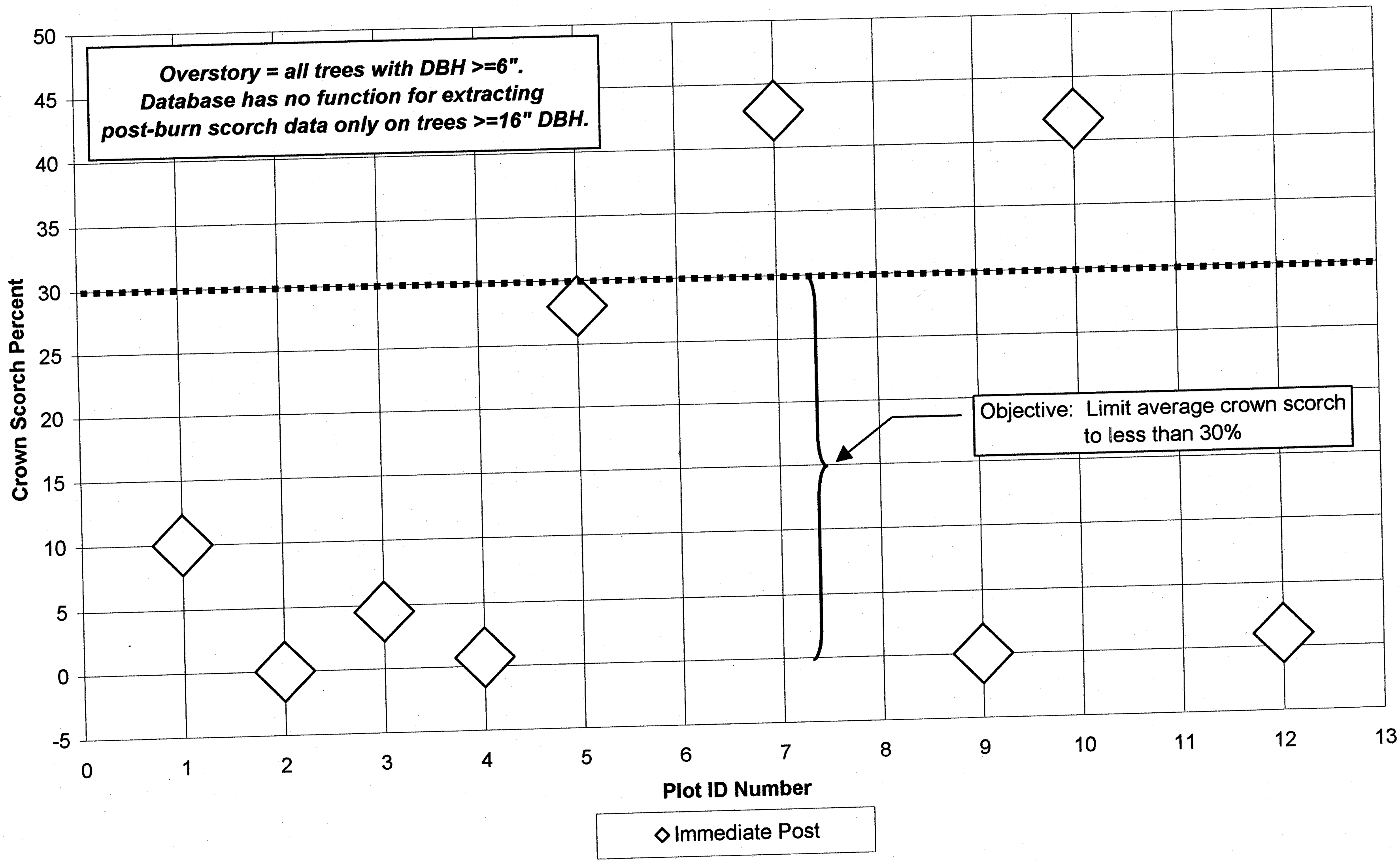


Figure 16. Post-burn Crown Scorch Percent on Live *Pinus ponderosa* Overstory Trees
December 2000

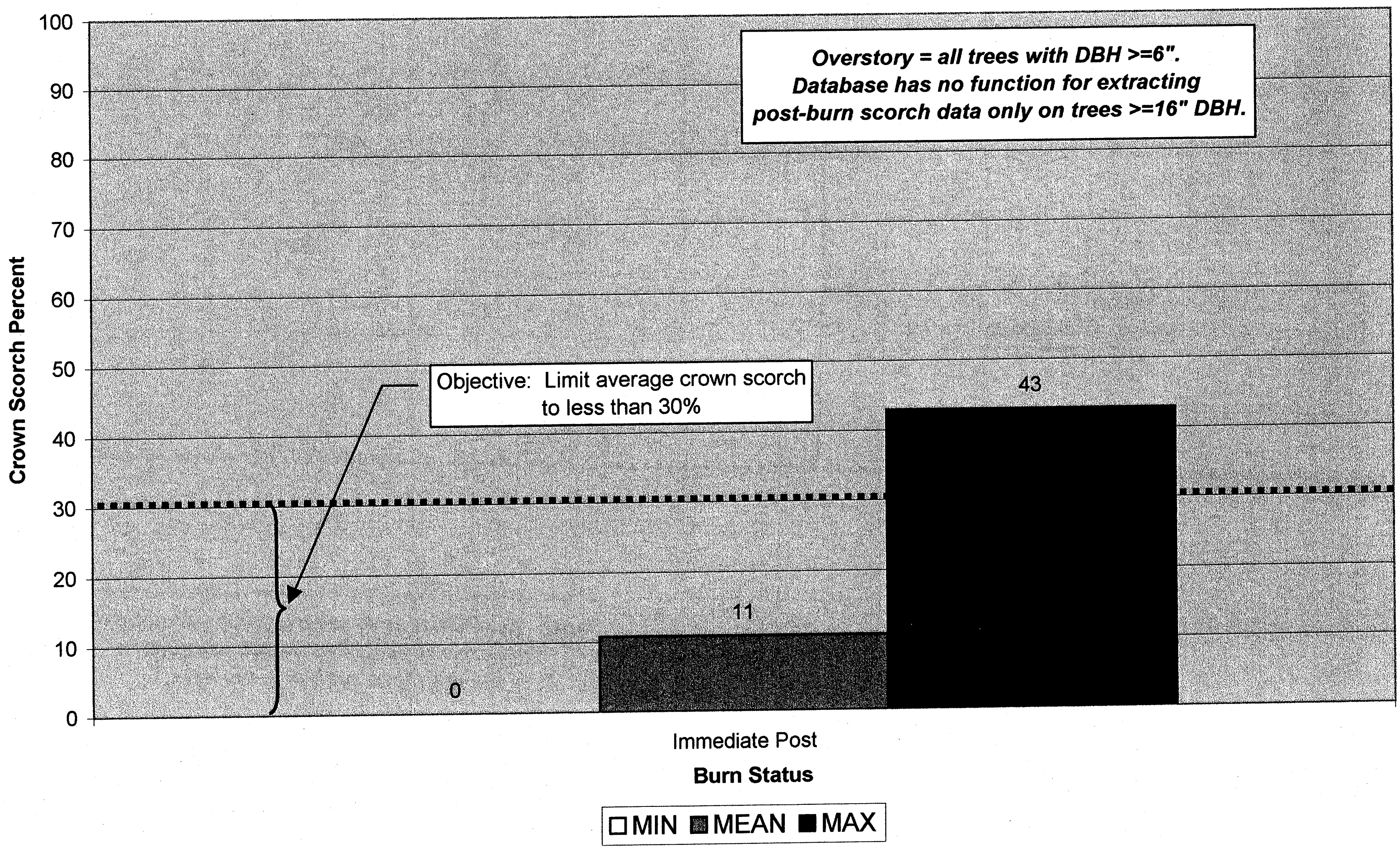


Figure 17. Total Fuel Load, by plot
December 2000
50-foot fuel transects

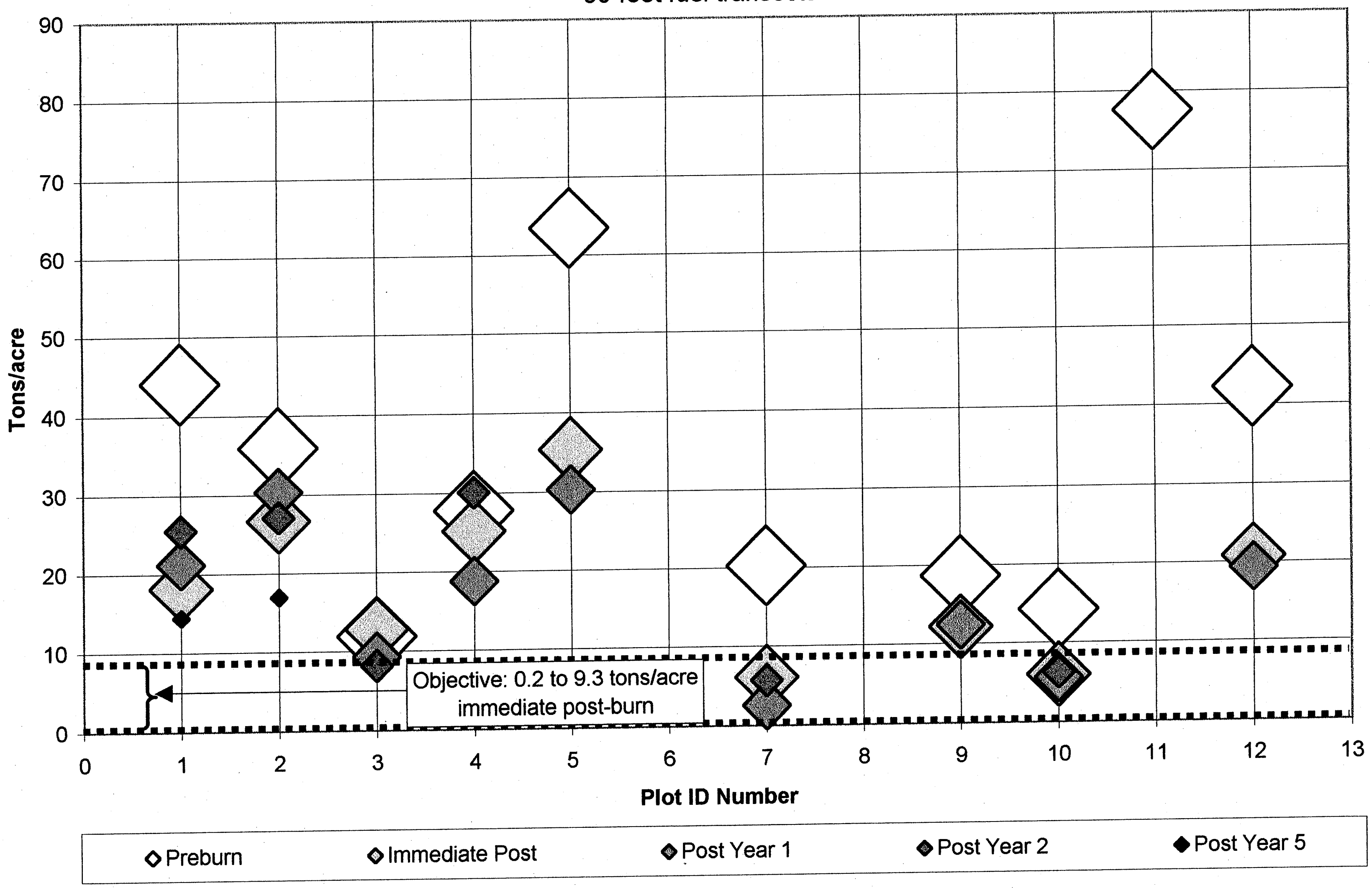


Figure 18. Total Mean Fuel Load
December 2000
50-foot fuels transects
n=9, *minimum required plots = 15*

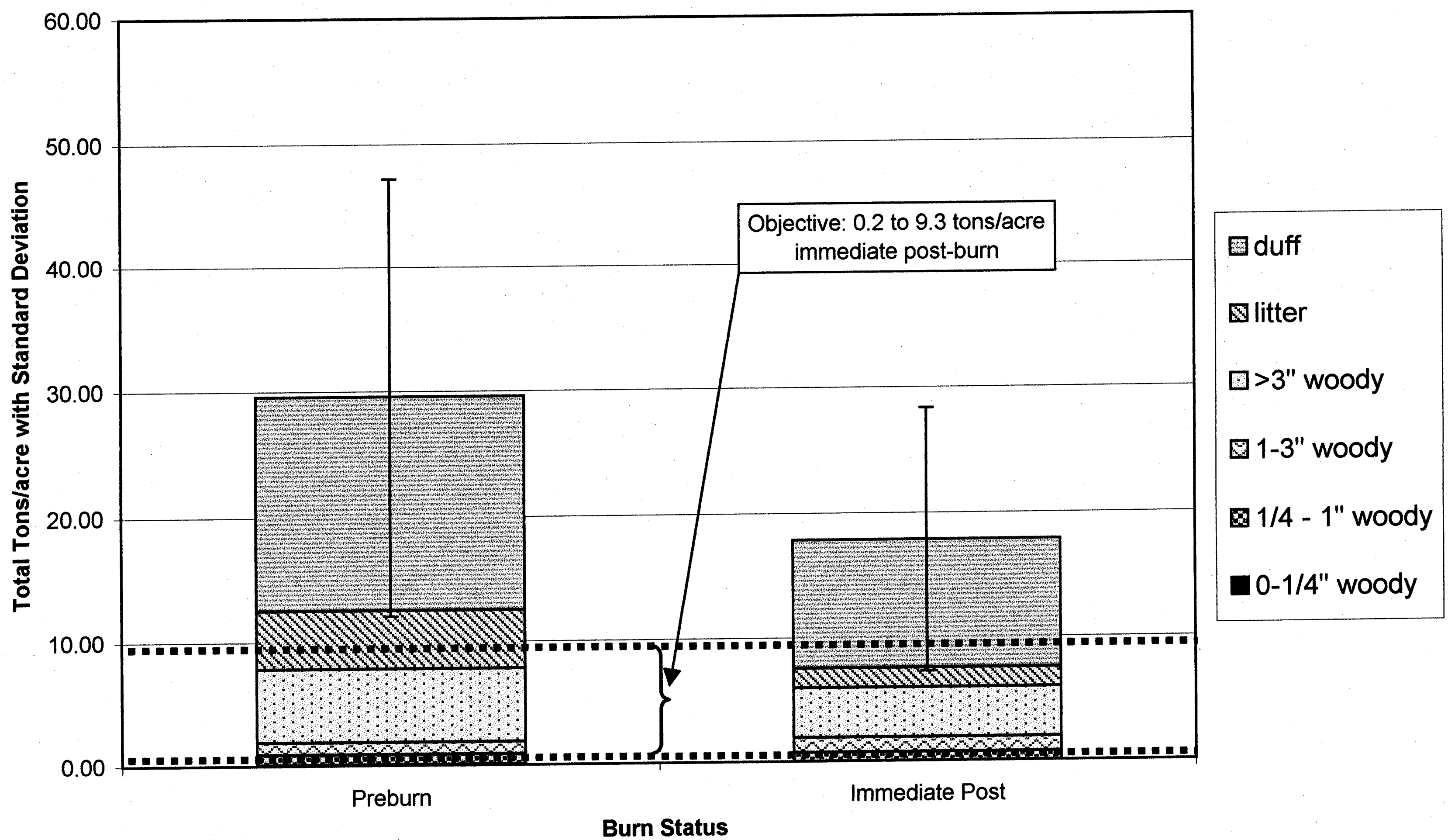


Figure 19. ***Pinus ponderosa*** **Pole Densities, by plot**
December 2000

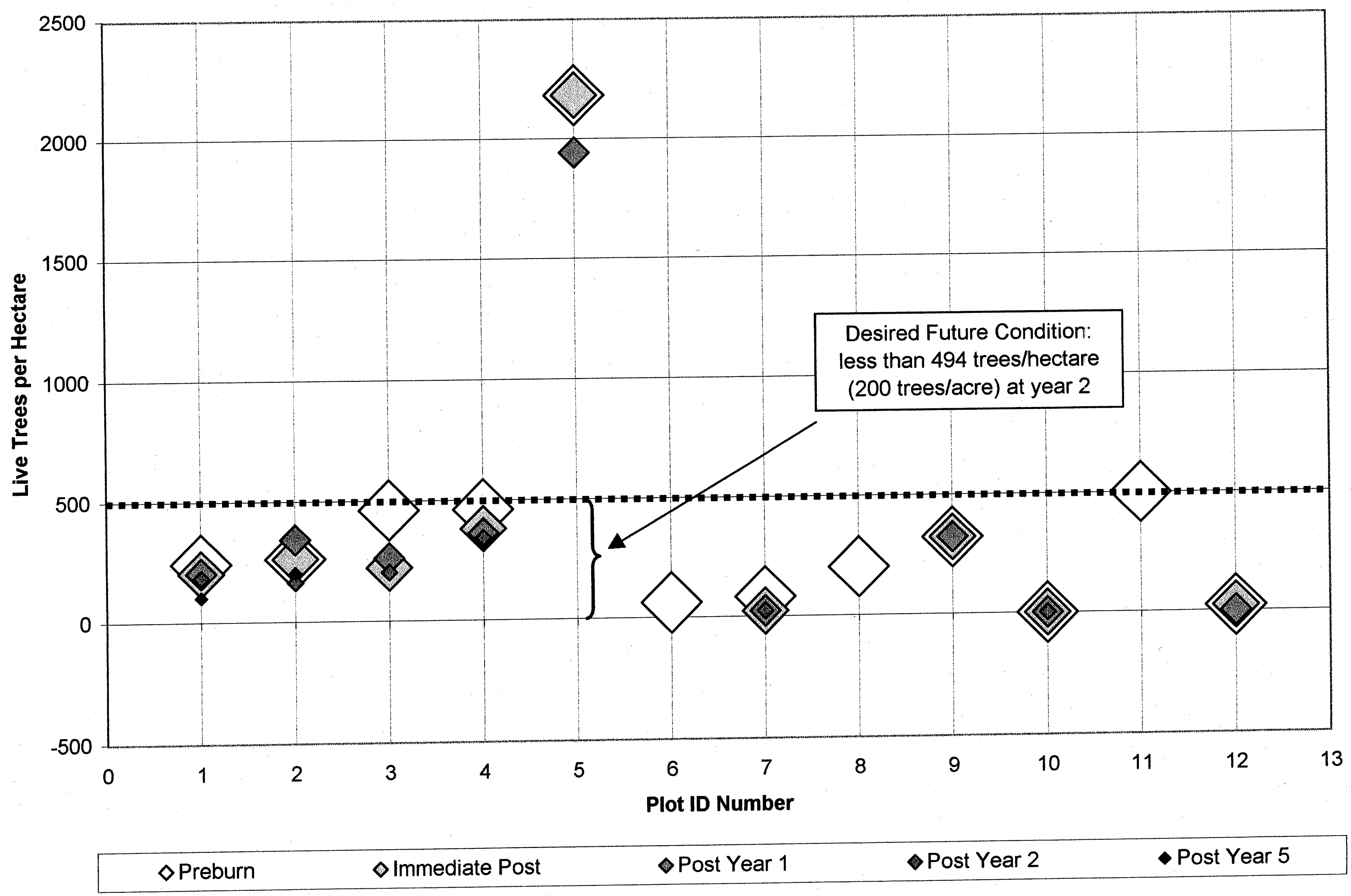


Figure 20. Mean *Pinus ponderosa* Pole Density
December 2000
n = 6 plots, *minimum required plots = 38*

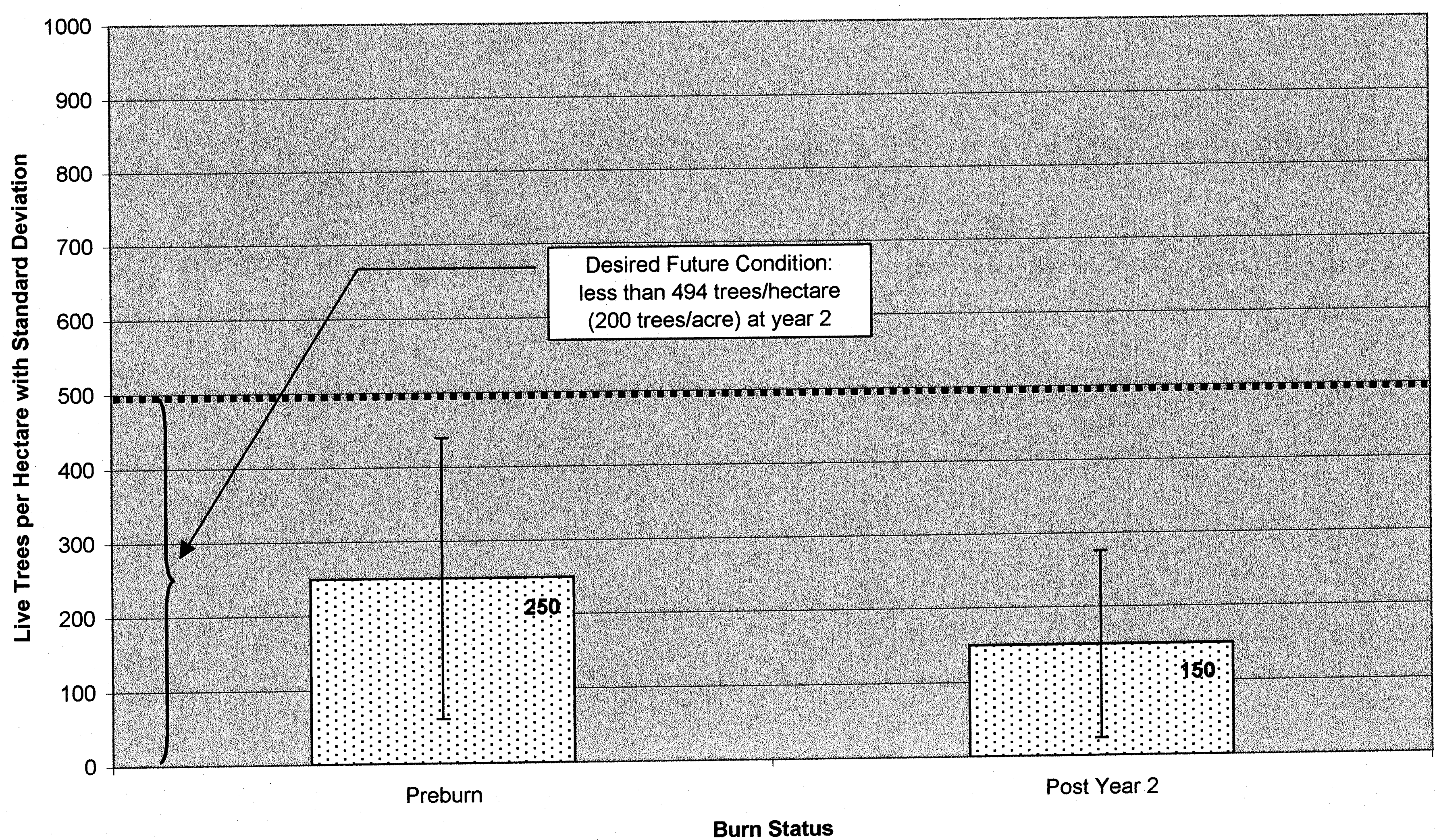


Figure 21. 6 - 15.9" DBH Snag Densities, by plot
December 2000

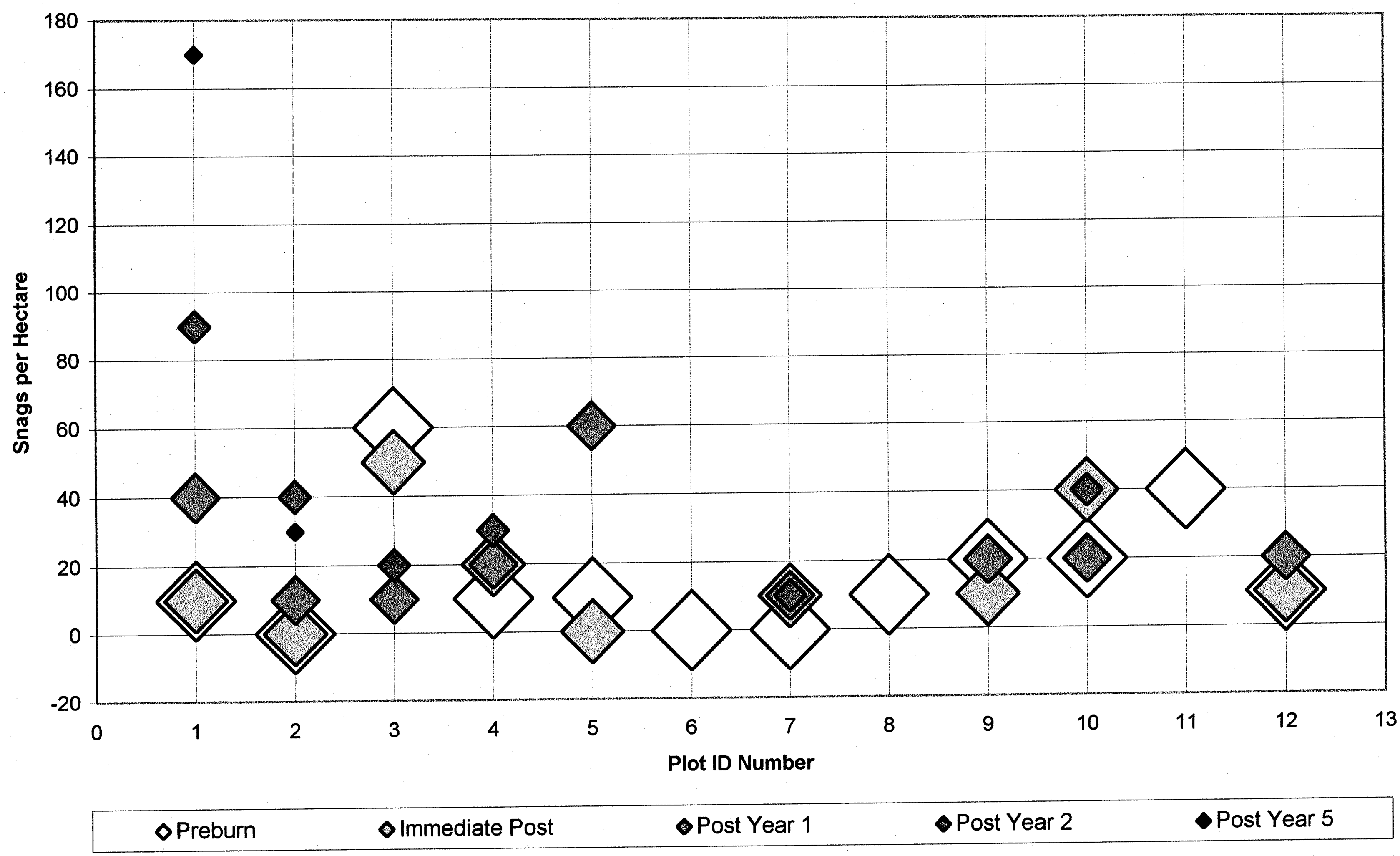


Figure 22. 16" DBH and larger Snag Densities, by plot
December 2000

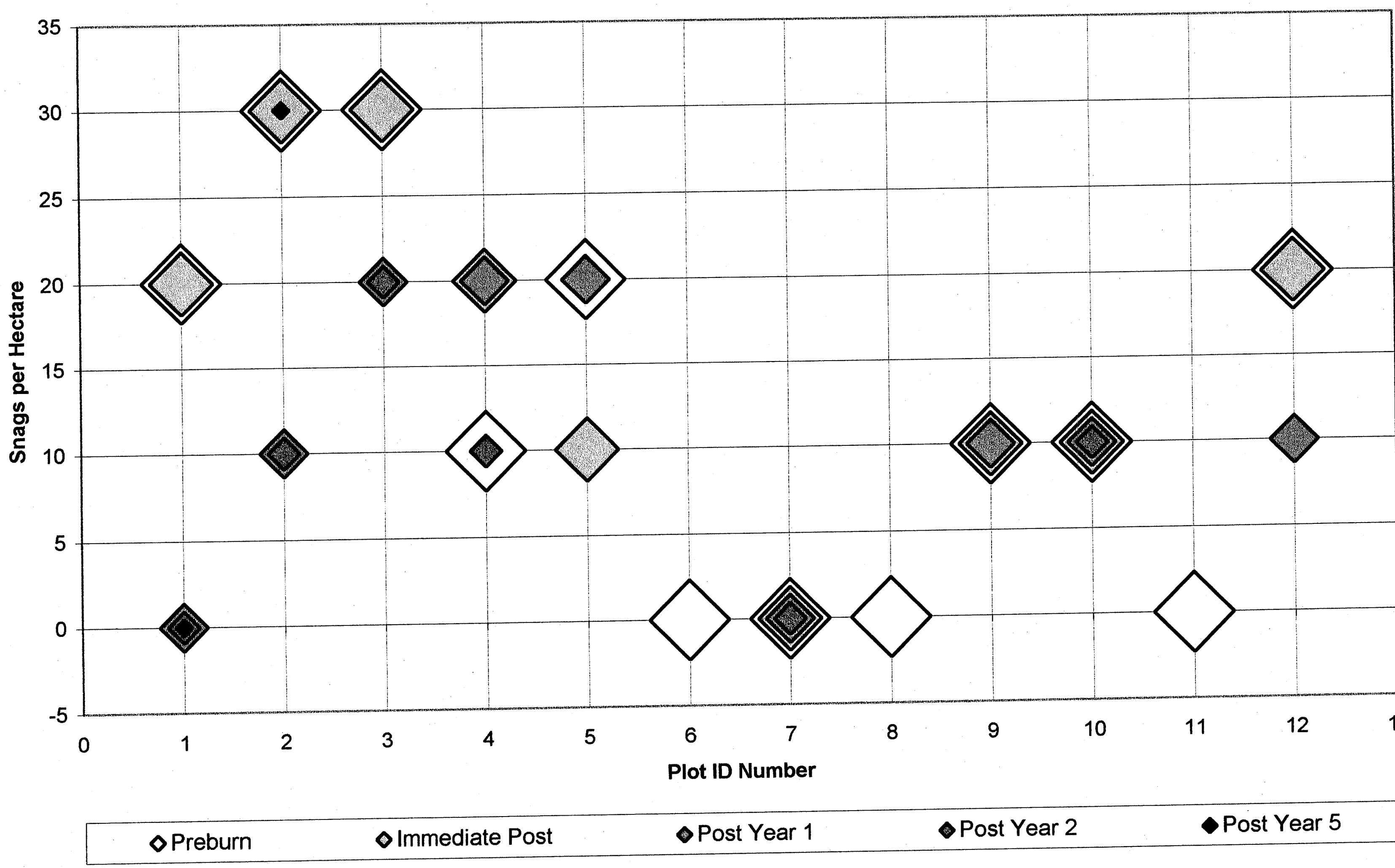


Figure 23. ***Abies concolor*** **Seedling Densities, by plot**
December 2000

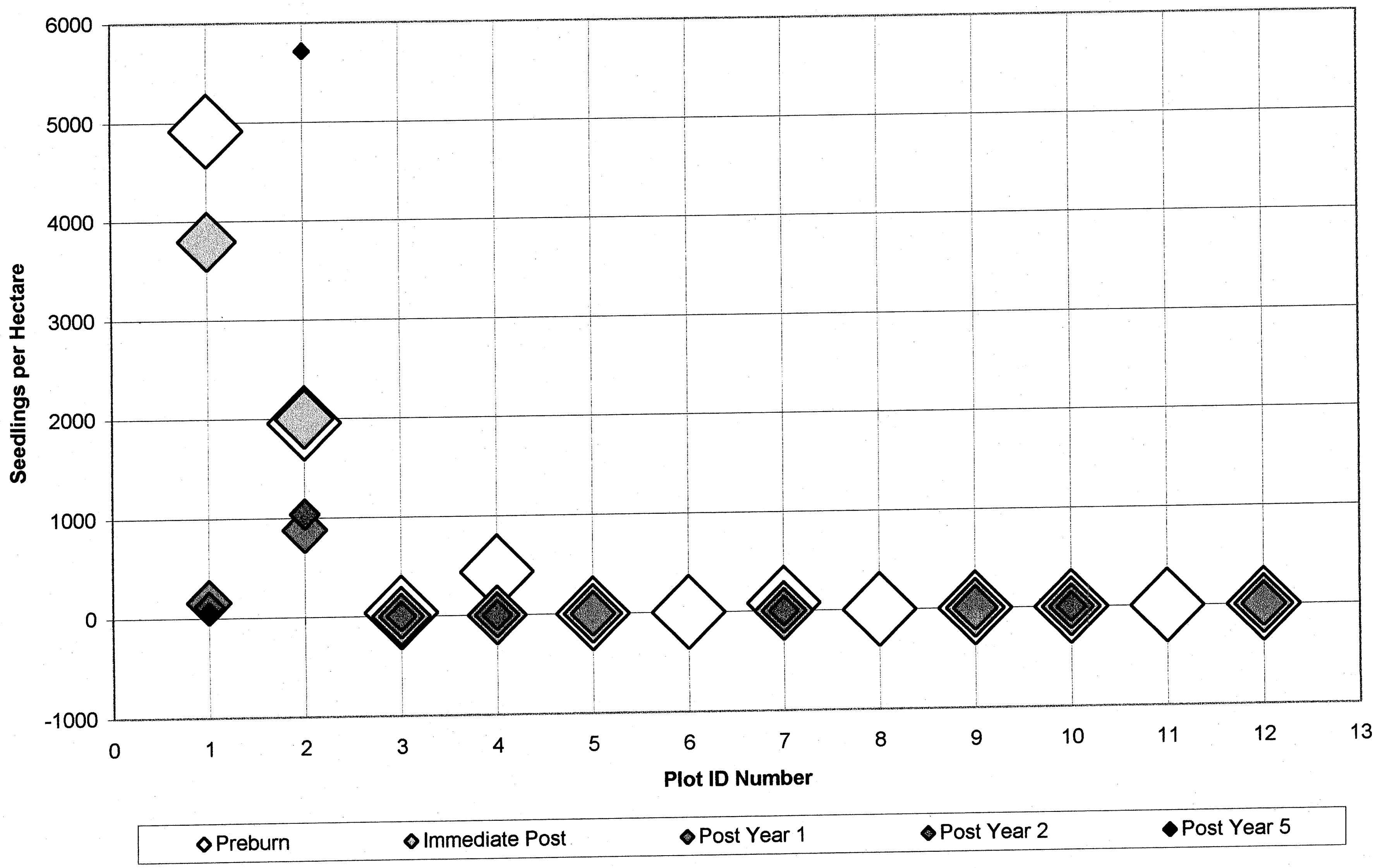


Figure 24. ***Pinus ponderosa*** **Seedling Densities, by plot**
December 2000

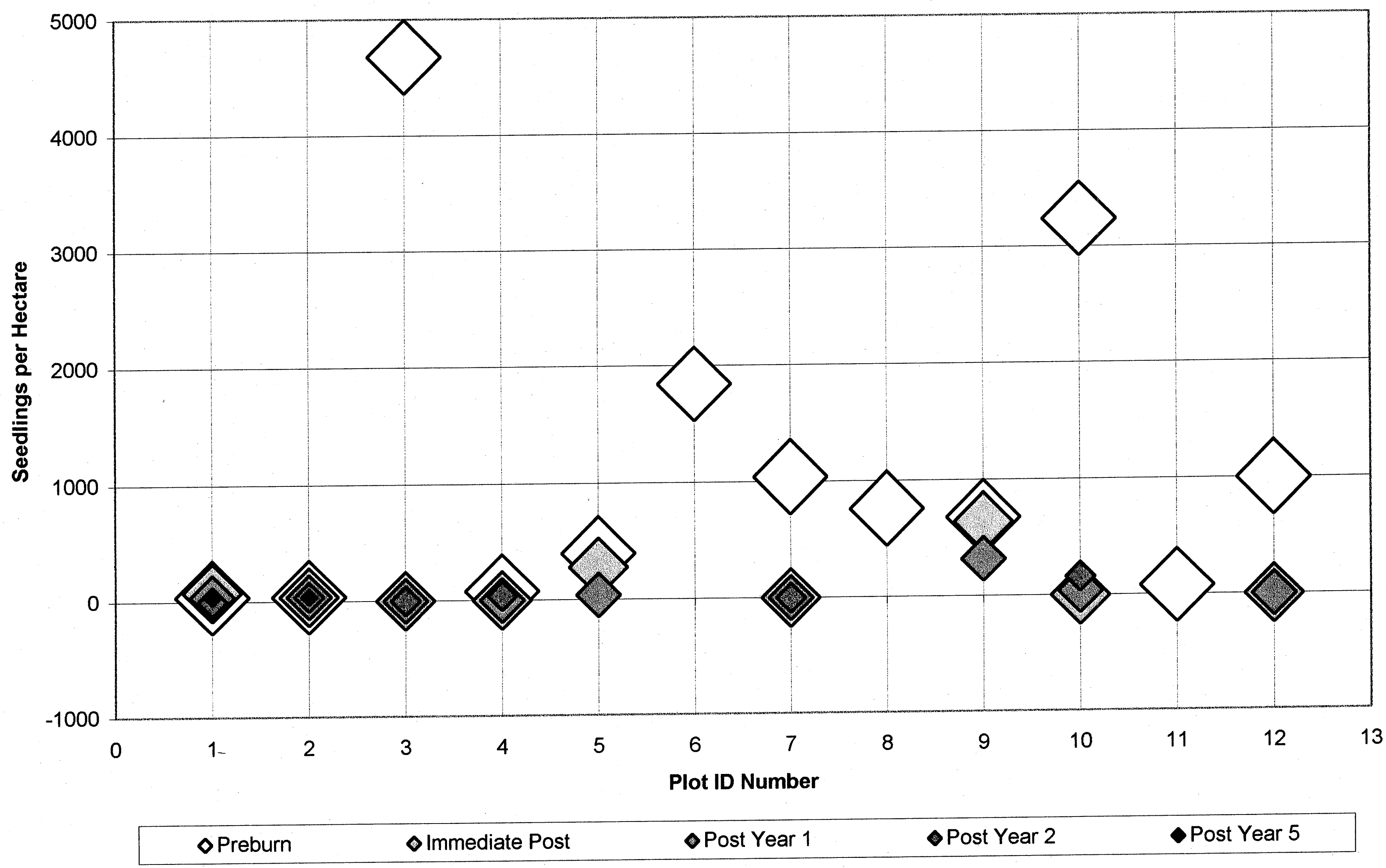
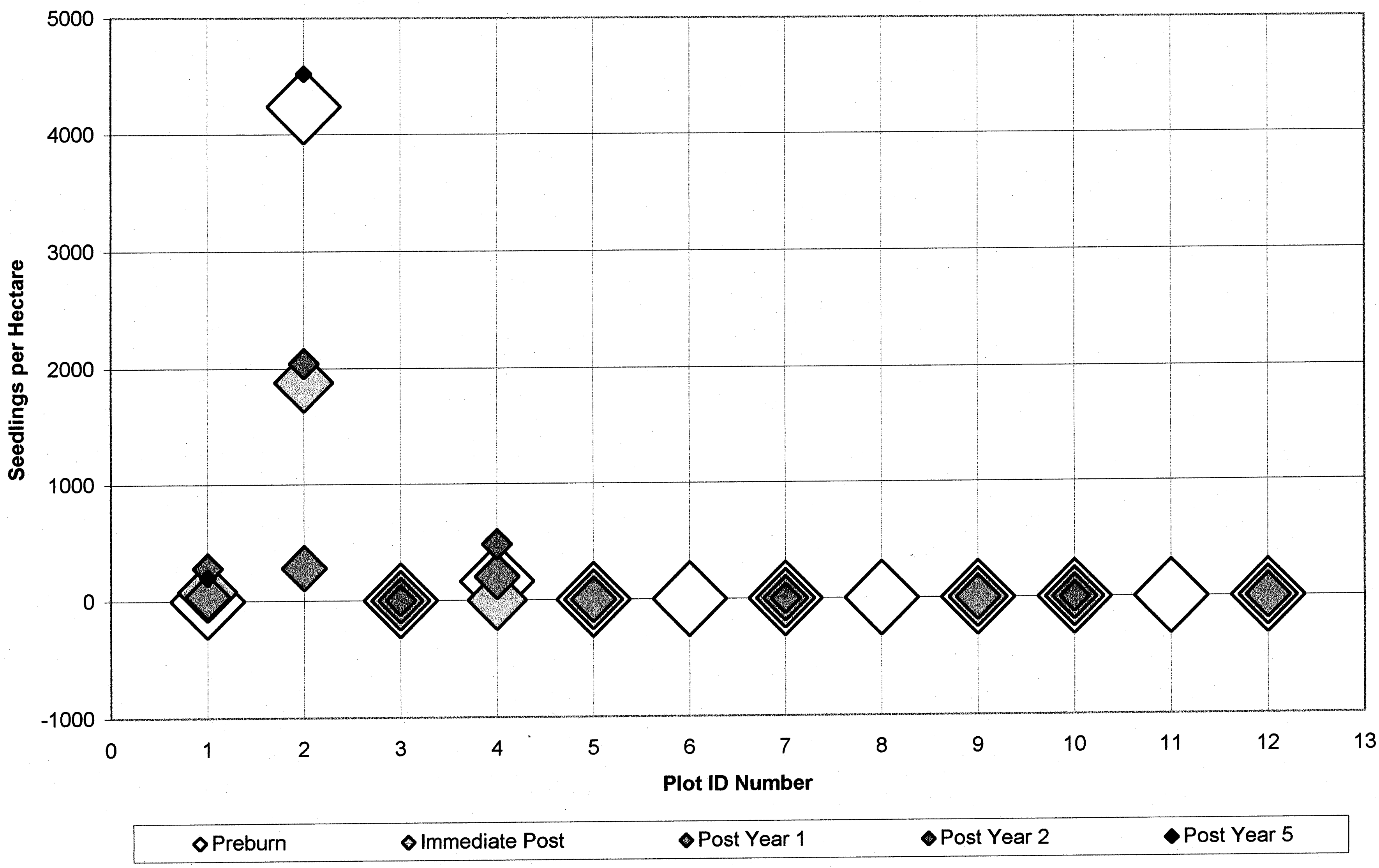


Figure 25. ***Populus tremuloides*** **Seedling Densities, by plot**
December 2000



PIAB RESULTS AND DISCUSSION

OVERSTORY DENSITY

Objective 1: Achieve and maintain an overstory ponderosa pine density (greater than or equal to 16" dbh) of 47-62 trees/hectare as stated in the Desired Future Condition, measured at five years post-burn. Note: *Pinus ponderosa* comprises less than 50% of overstory with remaining 50% occupied by mostly *Abies concolor* and *Populus tremuloides*.

Results: Figure 26 shows *Pinus ponderosa* live overstory densities for all plots. Most plots show little change over time, with densities decreasing only on plots 7 and 8, and increasing only on plot 12.

Was objective met? It is unknown whether or not this objective was met since there are not enough Post Year 5 data.

OVERSTORY SCORCH

Objective 2: Limit average crown scorch on overstory ponderosa pine (greater than or equal to 16" dbh) to 30%, measured immediately post-burn.

Results: At this time we cannot complete analysis for this variable. The database program (fmh.exe) does not allow assessment for scorch on trees of our unique size class. They can be compiled by hand at a future date. Figure 27 shows the data we *can* extract from the database—mean scorch per plot on all live ponderosas greater or equal to 6 inches (15 cm) dbh. This graph indicates no plots had a mean scorch of greater than 15% after the first-entry burn. Since this includes all trees from 6-16 inches (15-40 cm), it is likely that if they are taken out of the analysis, the mean scorch heights will be lower for trees greater than 16" (40 cm) dbh. Figure 28 shows minimum, mean, and maximum scorch heights after the first-entry burn.

Was objective met? Unknown, but likely met.

FUEL LOADING

Objective 3: Maintain an average total fuel load of 0.2 to 20 tons/acre as defined in the Desired Future Condition.

Results: Figure 29 shows the range of pre-burn fuel loads that exist in this monitoring type. Plot 7, in the Northwest III prescribed burn treated in 1993 and converted to a wildfire, shows a decrease in fuel load from 75 tons/hectare to 30 tons/acre. Figure 30 shows total mean fuel load preburn and postburn. Most of the change is in duff, litter, and large woody levels. Minimum plot requirements are met for this variable, therefore confidence intervals are shown on the graph, but they are wide for preburn and small for postburn, indicating less data variability was incurred after the treatment.

Was objective met? No, but trends are favorable. It is generally understood that more than one treatment is necessary to decrease fuel loading to desirable levels without achieving high mortality of overstory ponderosas.

Pole Density

Objective 4: Reduce pole densities to 0-247 trees/hectare by Post Year 2.

Results: Figure 31 illustrates the range of *Abies concolor* pole densities—approaching 1800 per hectare on one plot while zero on others. Figure 32 shows mean *Abies concolor* pole densities decreased from 309 to 166 trees/ha on 7 plots, but error bars are wide.

Was objective met? Unknown because minimum sample size not achieved, but trends are favorable.

Snag Density

Objective: Track snag densities over time.

Results: Figure 33 shows that small snag densities mostly increase after fire. Large snag densities in Figure 34 indicate both positive and negative changes on plots.

Was objective met? There is no objective for a certain number of snags at this time. Consultation with the Grand Canyon National Park wildlife biologist is needed to define an objective.

Seedling Density

Objective: Track seedling densities over time.

Results: Figure 35 shows *Abies concolor* seedling densities across the monitoring network—trends per plot vary. Figure 36 indicates there are few plots with any *Pinus ponderosa* seedlings at all, and there are both increases and decreases on those that have burned. Figure 37 shows *Populus tremuloides* seedlings usually increase when burned.

Was objective met? There is no objective for seedling densities at this time. This information is provided for general knowledge, so that other resource management staff at Grand Canyon are aware of the trends.

Figure 26. Live 16" DBH and larger *Pinus ponderosa* Densities, by plot
December 2000

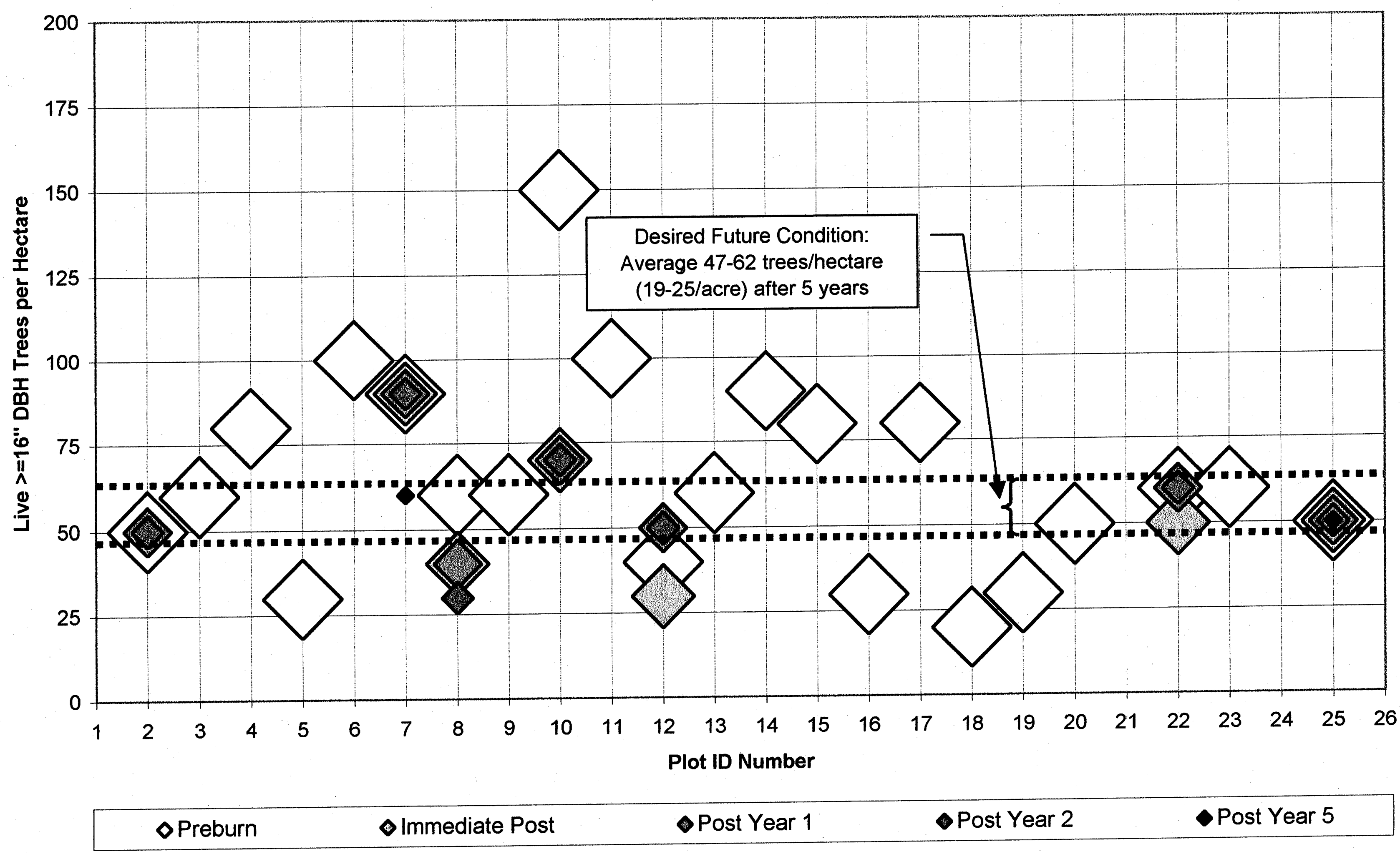


Figure 27. Post-burn Crown Scorch Percent on Live *Pinus Ponderosa* Overstory Trees, by plot
December 2000

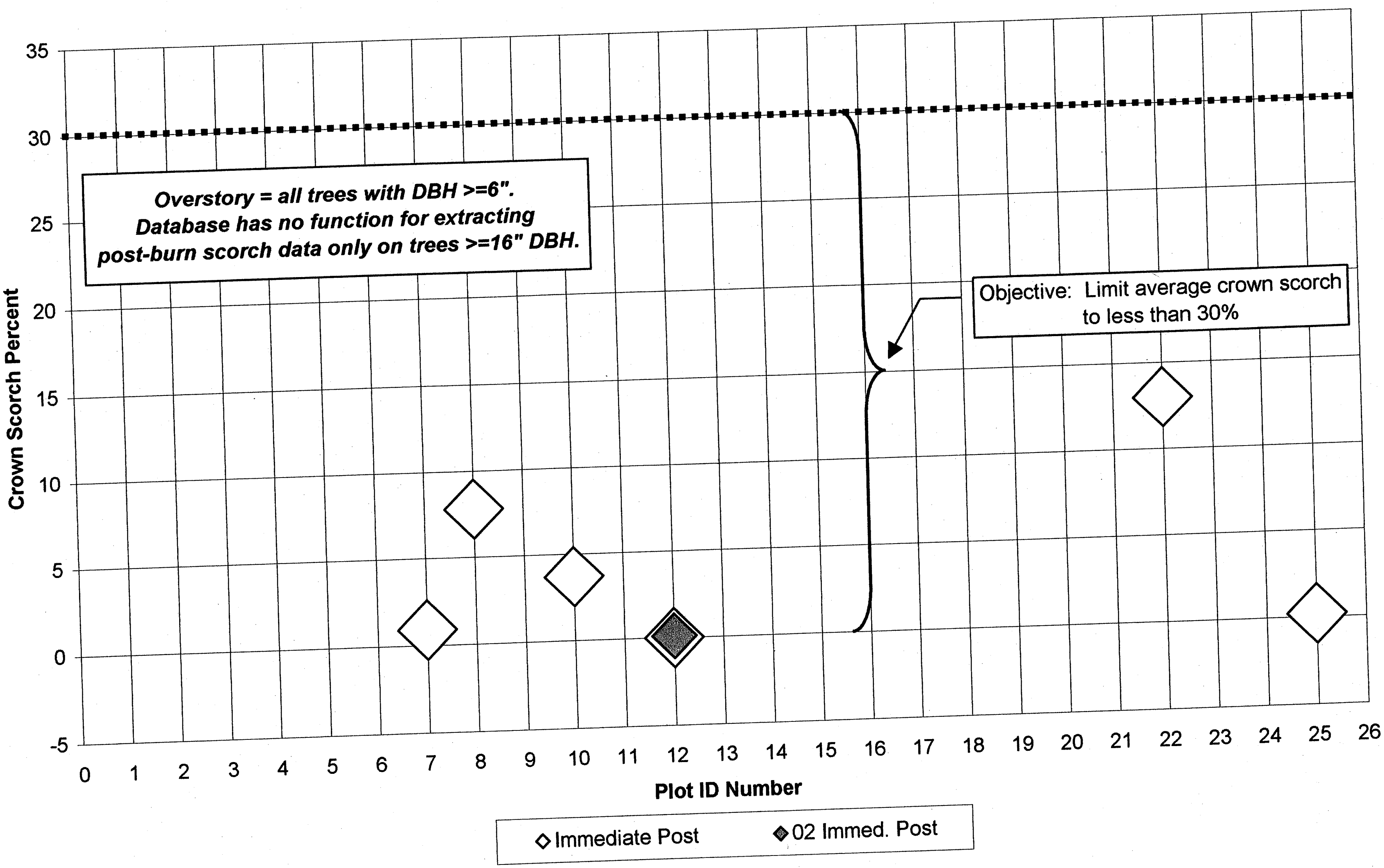


Figure 28. Post-burn Crown Scorch Percent on Live *Pinus ponderosa* Overstory Trees
December 2000

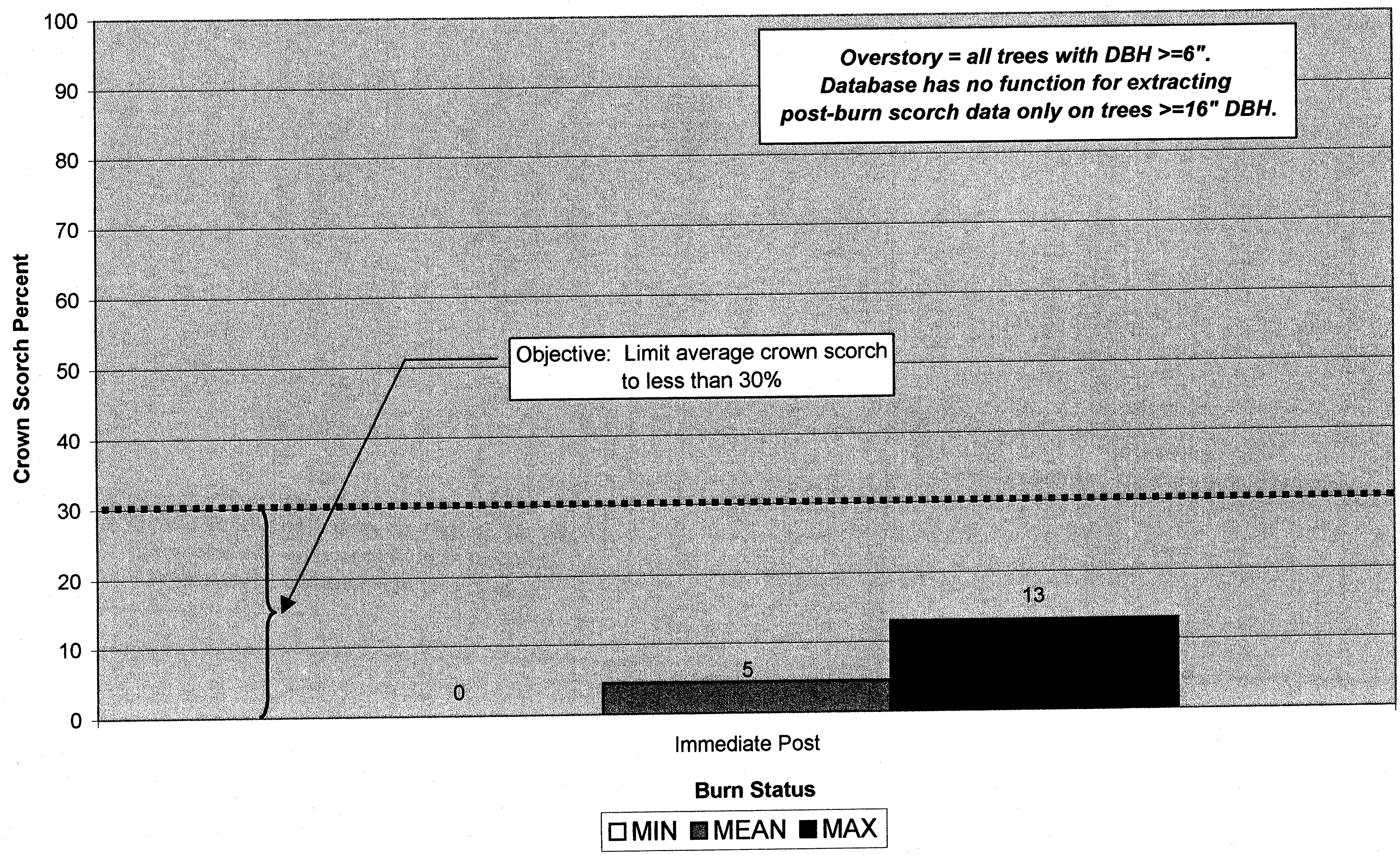


Figure 29. Total Fuel Load, by plot
December 2000
50-foot fuel transects

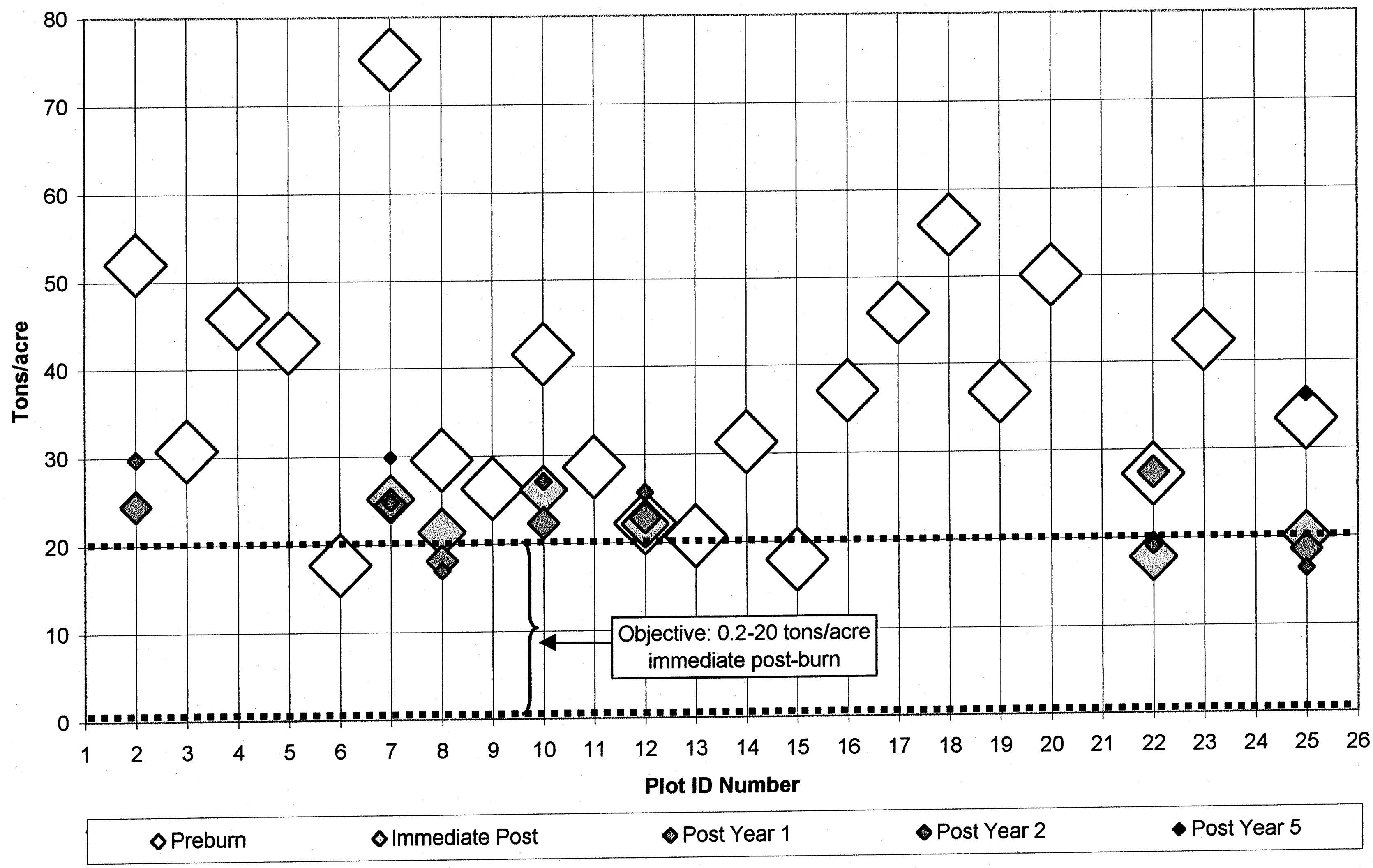


Figure 30. Total Mean Fuel Load
December 2000
50-foot fuels transects
n=6, *minimum required plots = 1*

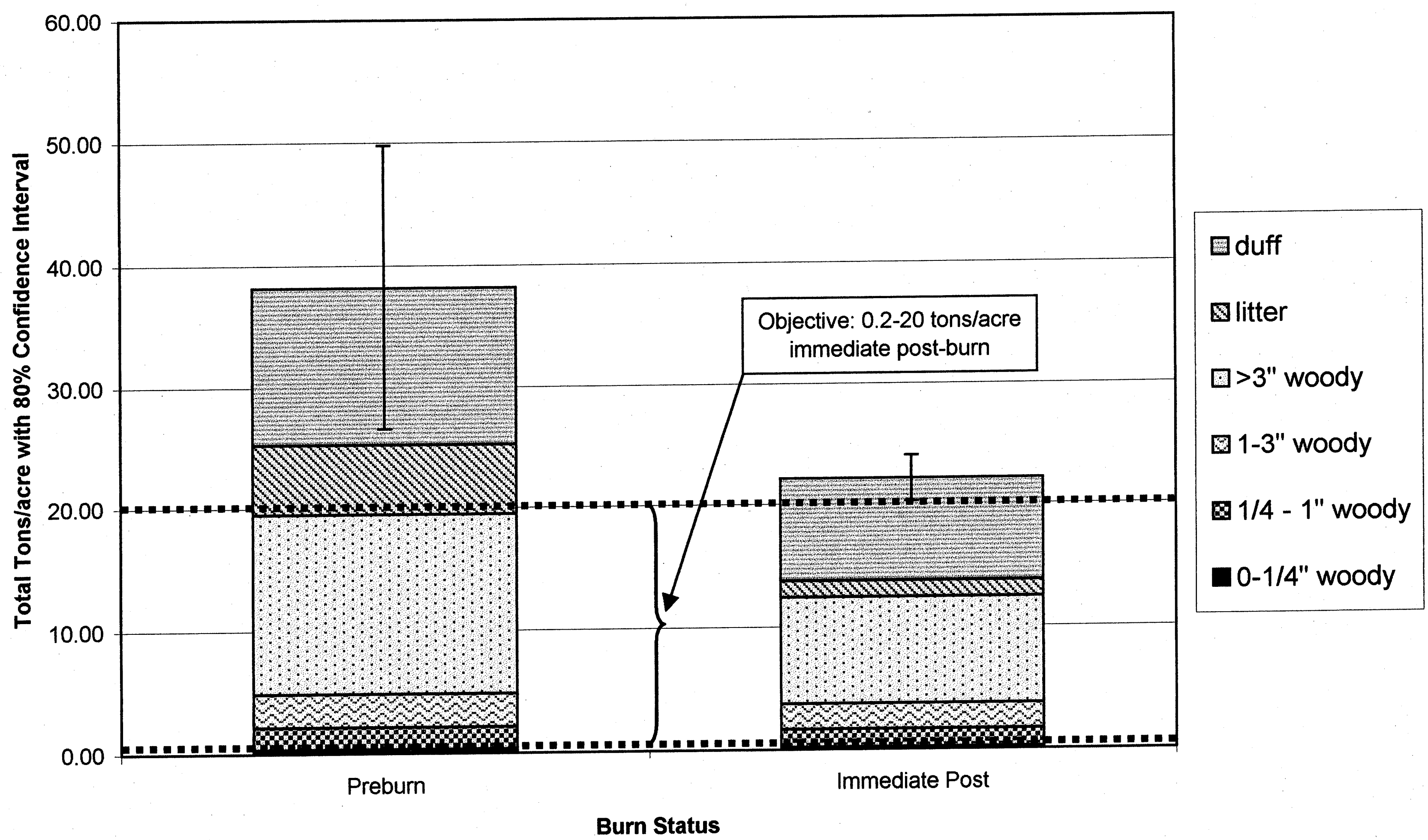


Figure 32. ***Abies concolor*** **Pole Densities, by plot**
December 2000

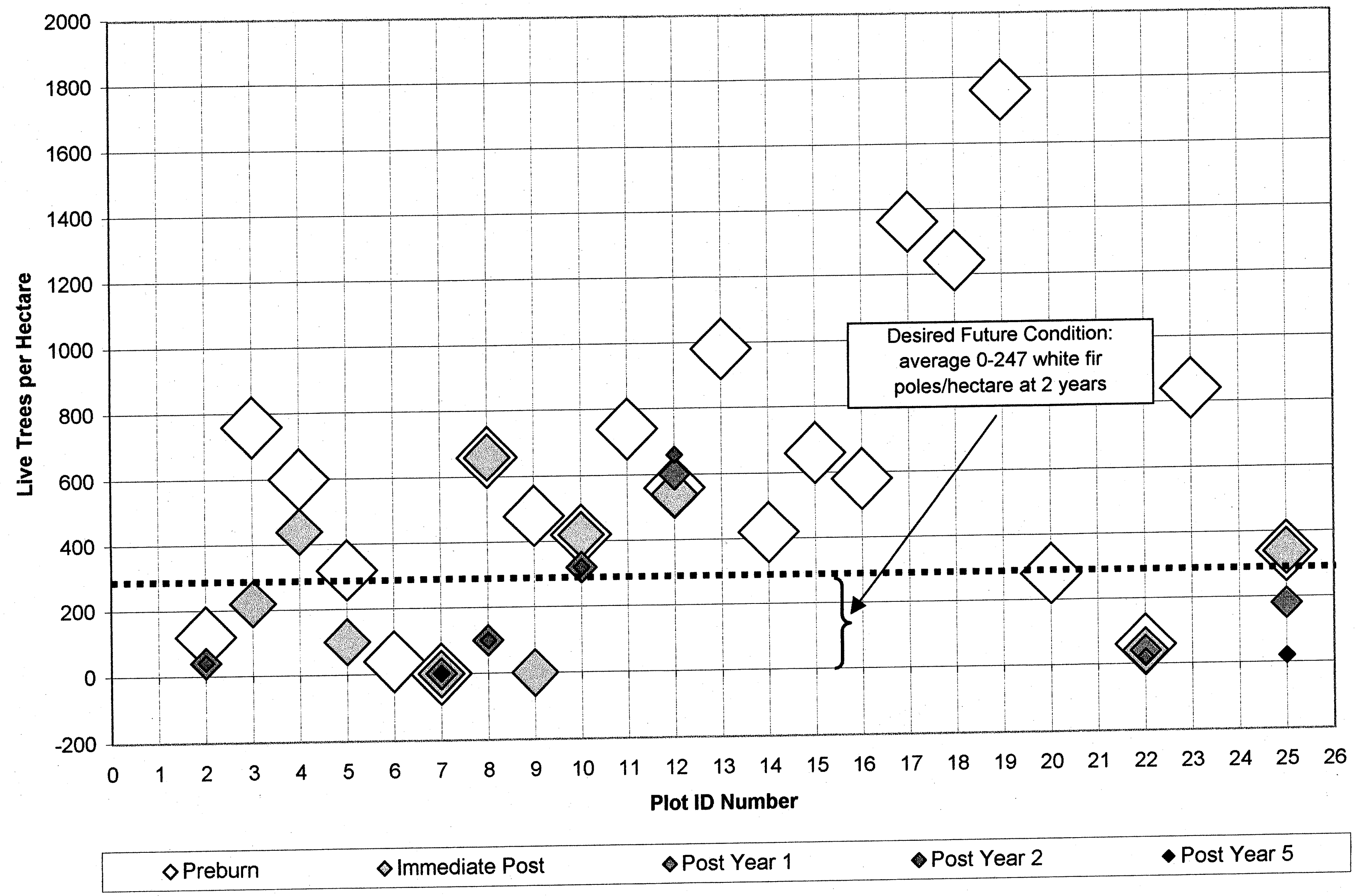


Figure 32. Mean *Abies concolor* Pole Density
December 2000
n = 7, *minimum required plots = 113*

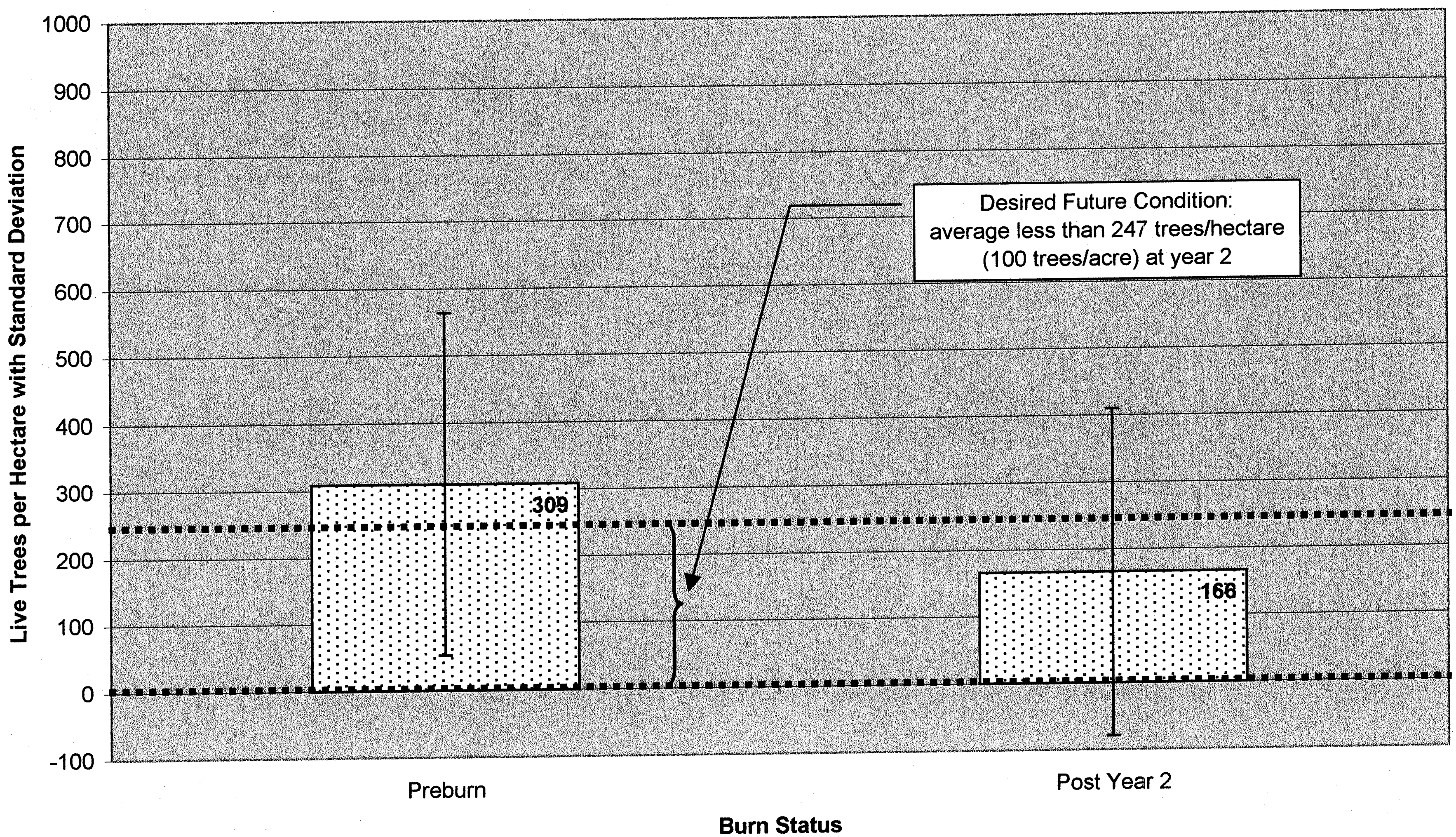


Figure 33. 6 - 15.9" DBH Snag Densities, by plot
December 2000

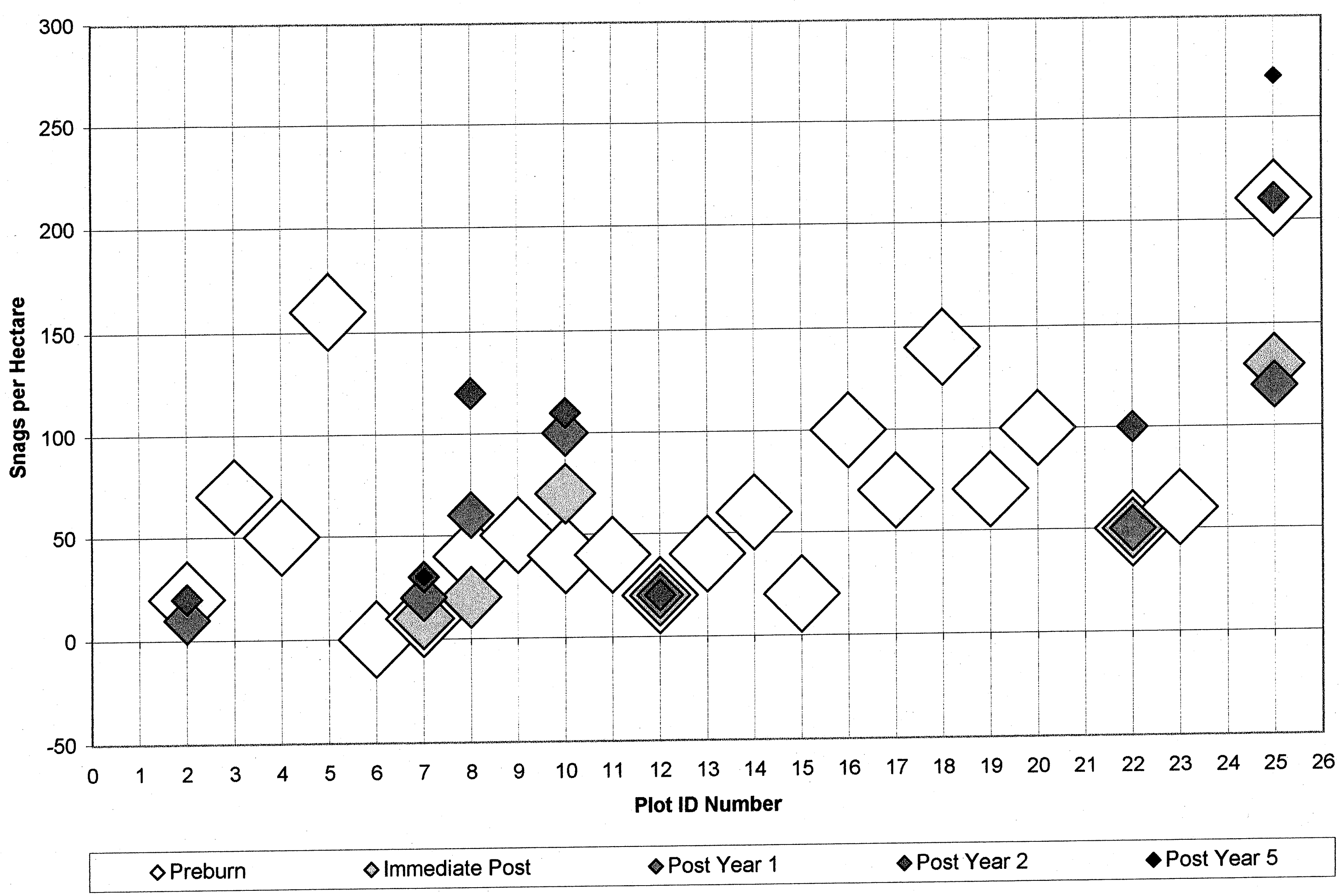


Figure 34. 16" DBH and larger Snag Densities, by plot
December 2000

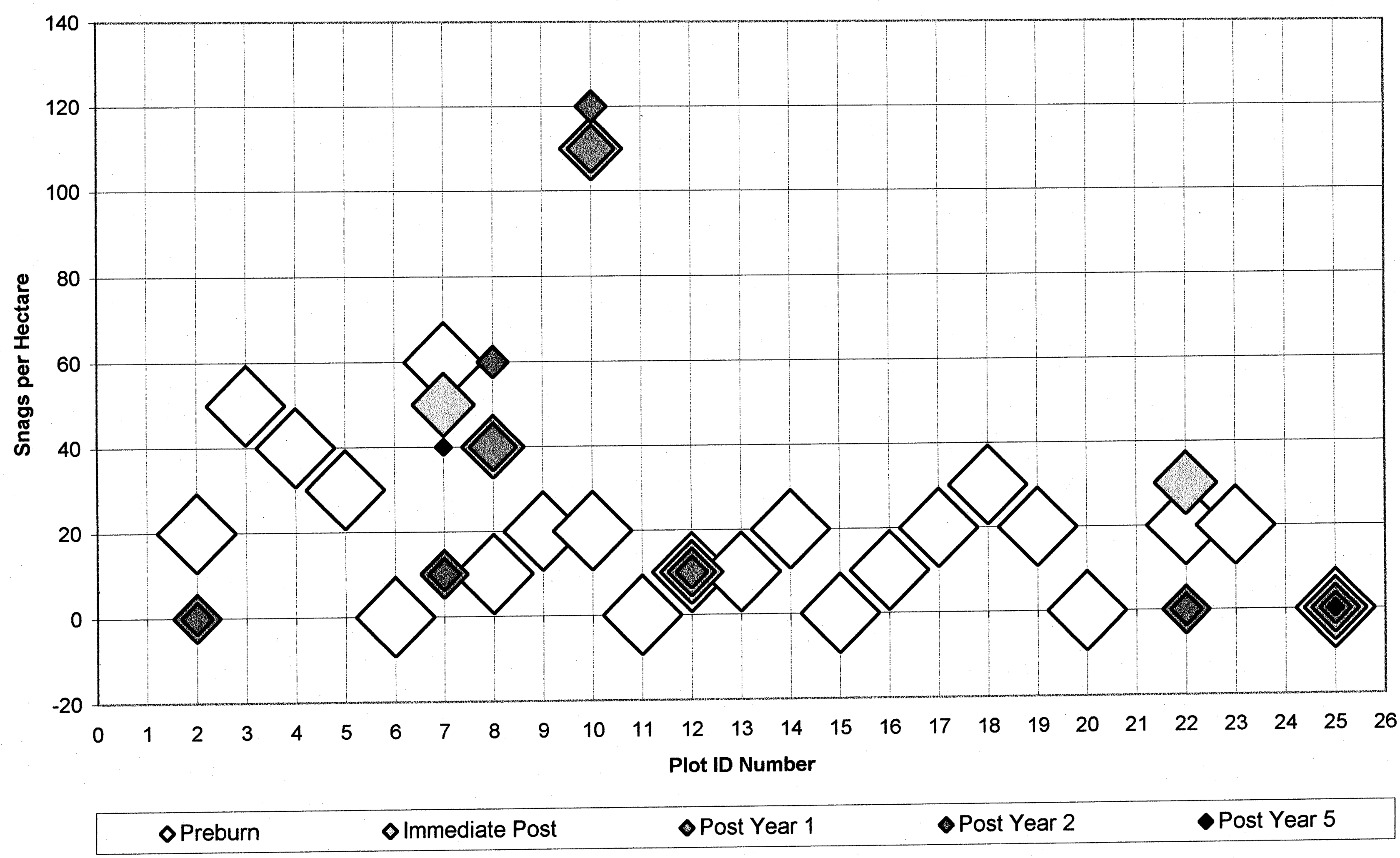


Figure 35. ***Abies concolor*** **Seedling Densities, by plot**
December 2000

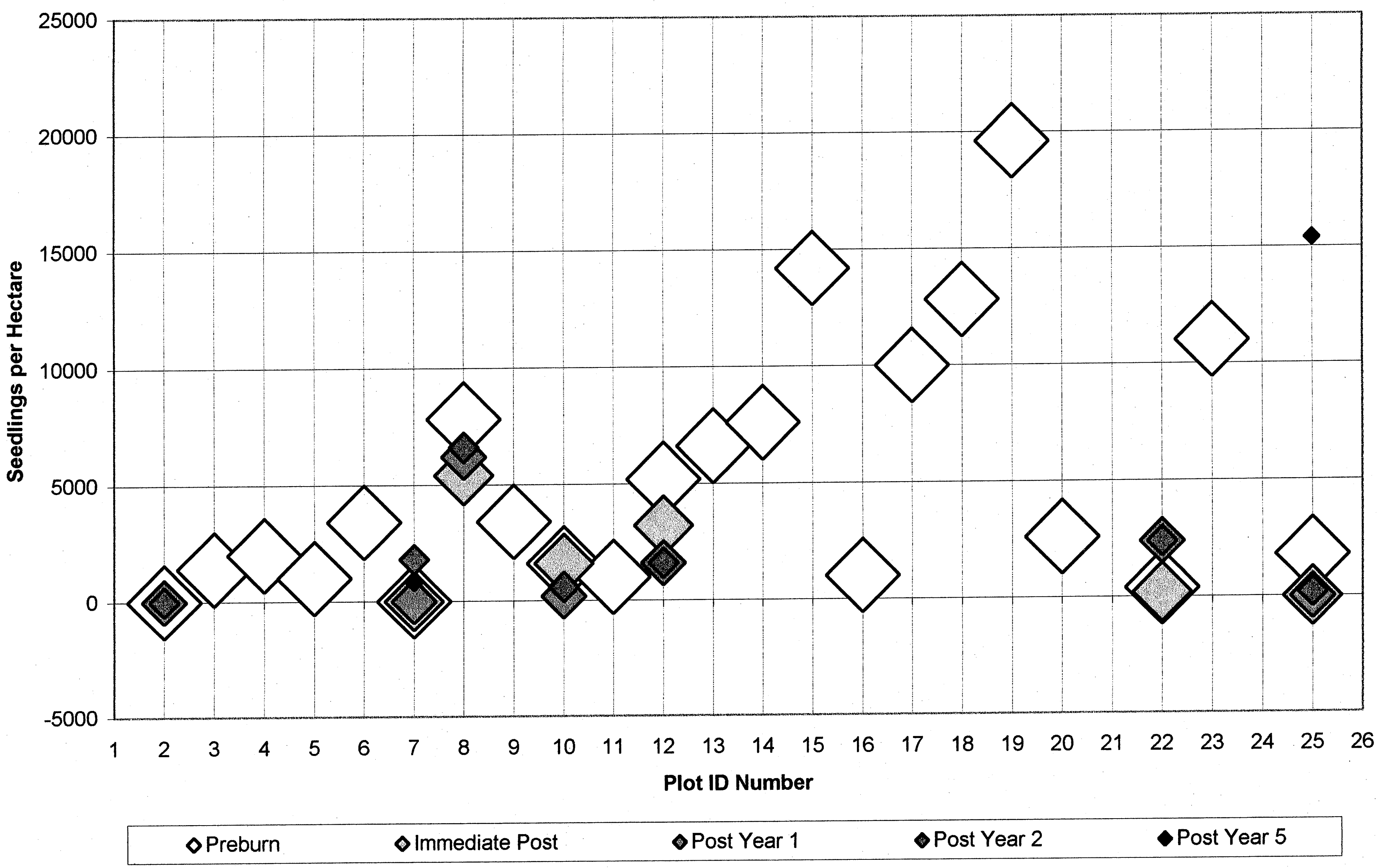


Figure 36. *Pinus ponderosa* Seedling Densities, by plot
December 2000

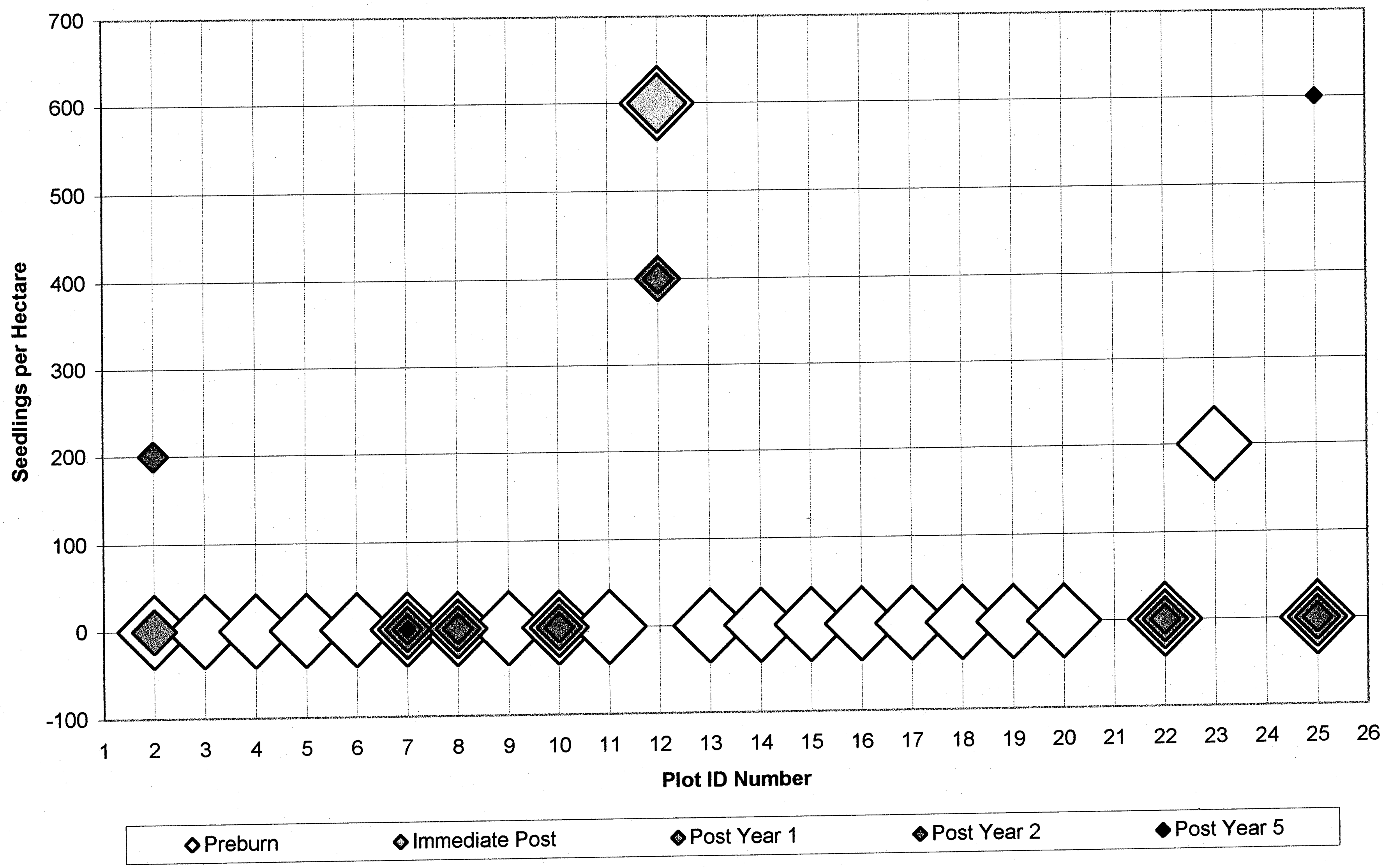
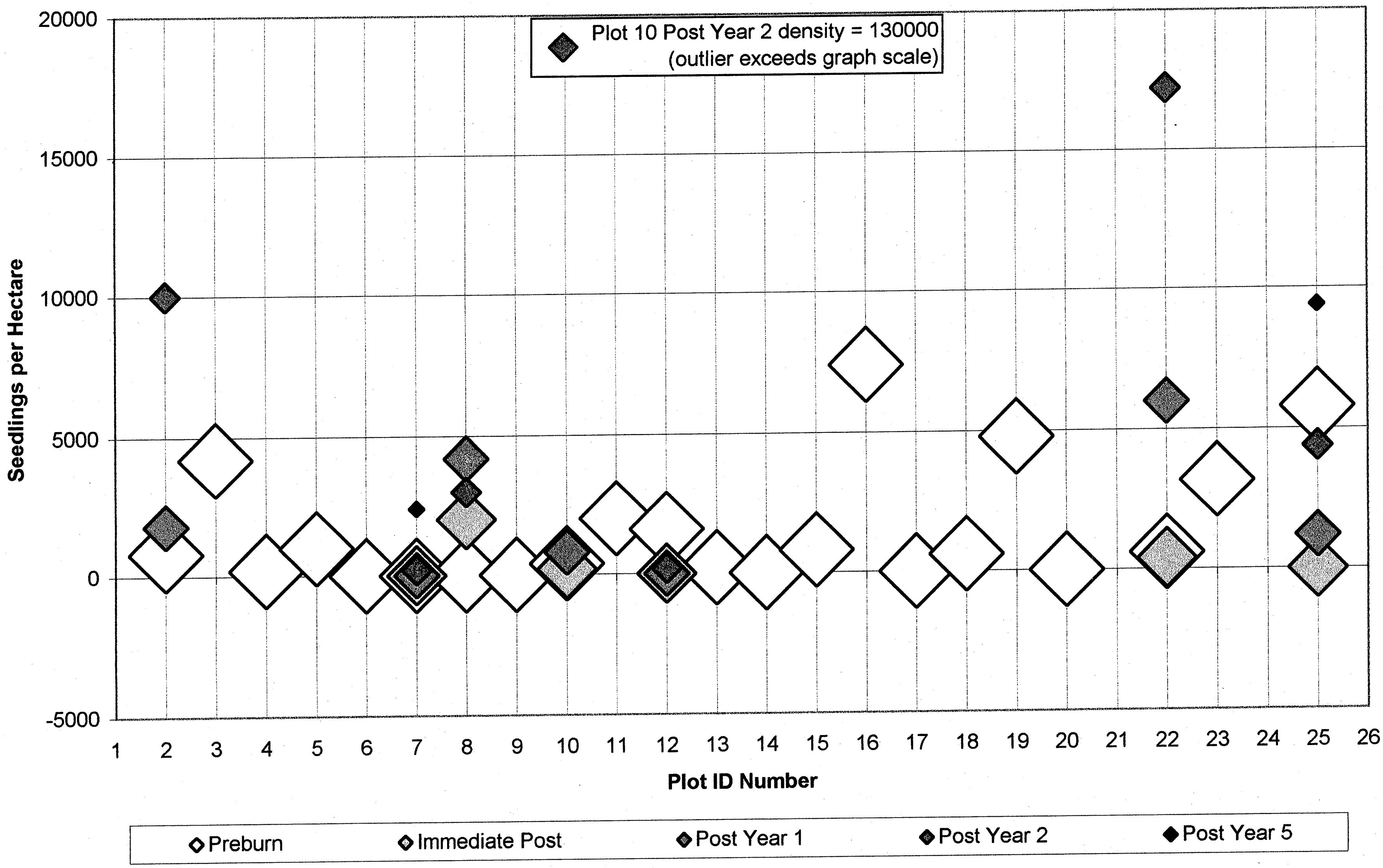


Figure 37. ***Populus tremuloides*** **Seedling Densities, by plot**
December 2000



SUMMARY OF RESULTS

Table 12 shows results for all variables that have specific monitoring objectives identified in FMH-4s. After over 8 years of fire monitoring, only one of the variables can be assessed with confidence due to a lack of statistically significant plot data. This does not mean the plots have not been installed. In some cases, the plots are there, but they may not have burned, or they may have been burned only recently; therefore data to assess overstory at 5 years postfire is not collected yet. In other cases, however, plot installs are again scheduled for the next field season.

This table illustrates the problems that result from not installing plots on schedule. If plots had been installed in 1994 and 1995, 5-year data would be available today to assess these variables with confidence. The effects of delaying plot installs are not immediately apparent. It may be years after the burn when the data suddenly become important to justify the prescribed fire program, only to find that they are not available for five more years. If prescribed burning becomes a controversial issue in the future, we do not have the local data to support this program. This is a serious issue that should be addressed by the GRCA Fire Management staff, the Science Center staff, and the Regional Fire Ecologist.

Table 12. Summary of Results for variables with specific objectives.

Monitoring Type	Variable	Minimum Samples Achieved? Y/N	Objective Achieved? Y/N/Unknown
PIPO	Overstory (PIPO)	N	Unknown
	Fuel Load	N	Unknown
	Poles (PIPO)	N	Unknown
PIPN	Overstory (PIPO)	N	Unknown
	Fuel Load	N	Unknown
	Poles (PIPO)	N	Unknown
PIAB	Overstory (PIPO)	N	Unknown
	Fuel Load	Y	N
	Poles (ABCO)	N	Unknown
PIEN	Overstory (mixed)	N	Unknown
	Fuel Load	N	Unknown

Appendix A. Preliminary Outlet Fire Data

Figure 1. Live 16" DBH and larger *Pinus ponderosa* Densities, by plot, PIAB Monitoring Type
December 2000

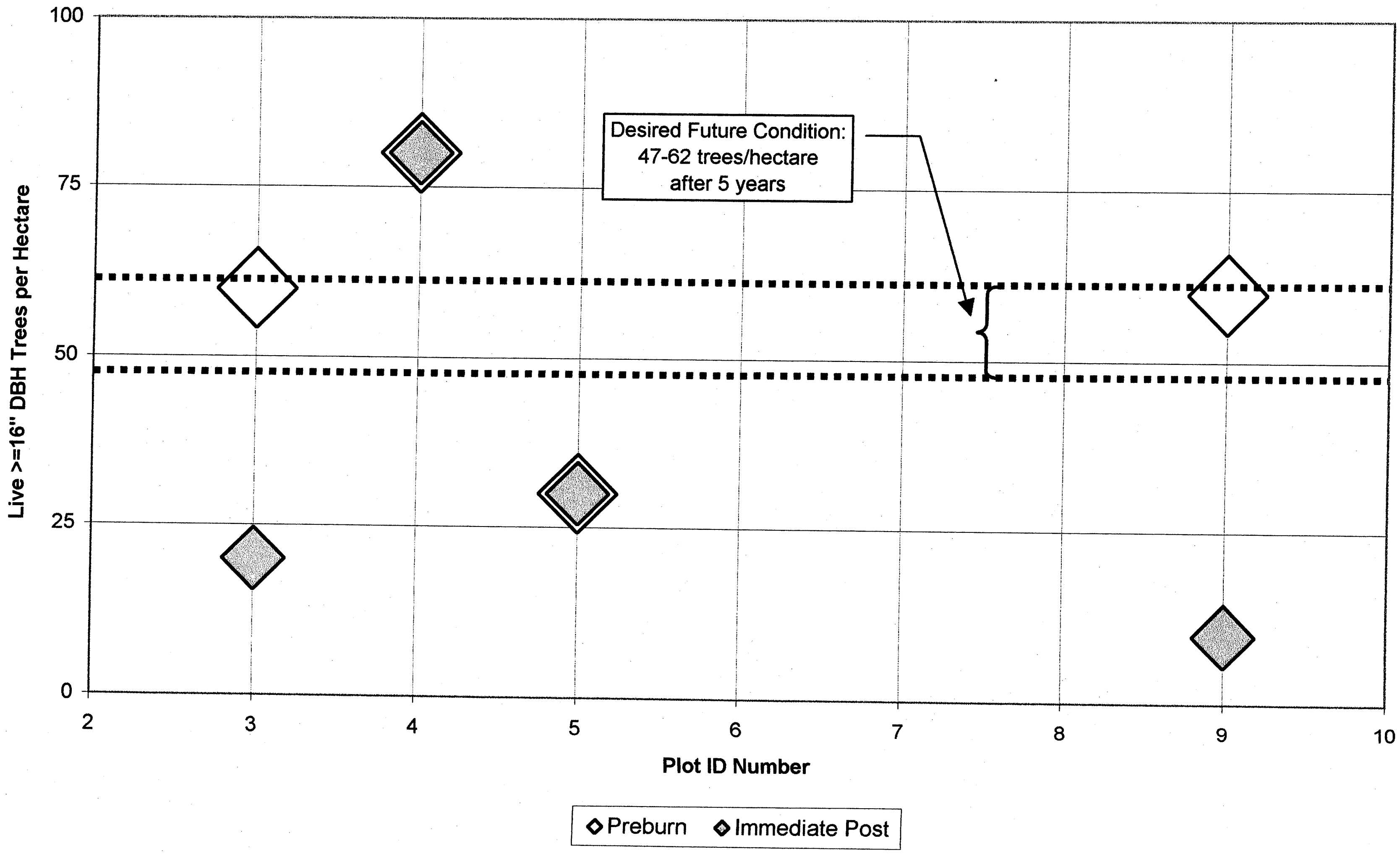


Figure 2. Total Fuel Load, by plot

December 2000

50-foot fuel transects

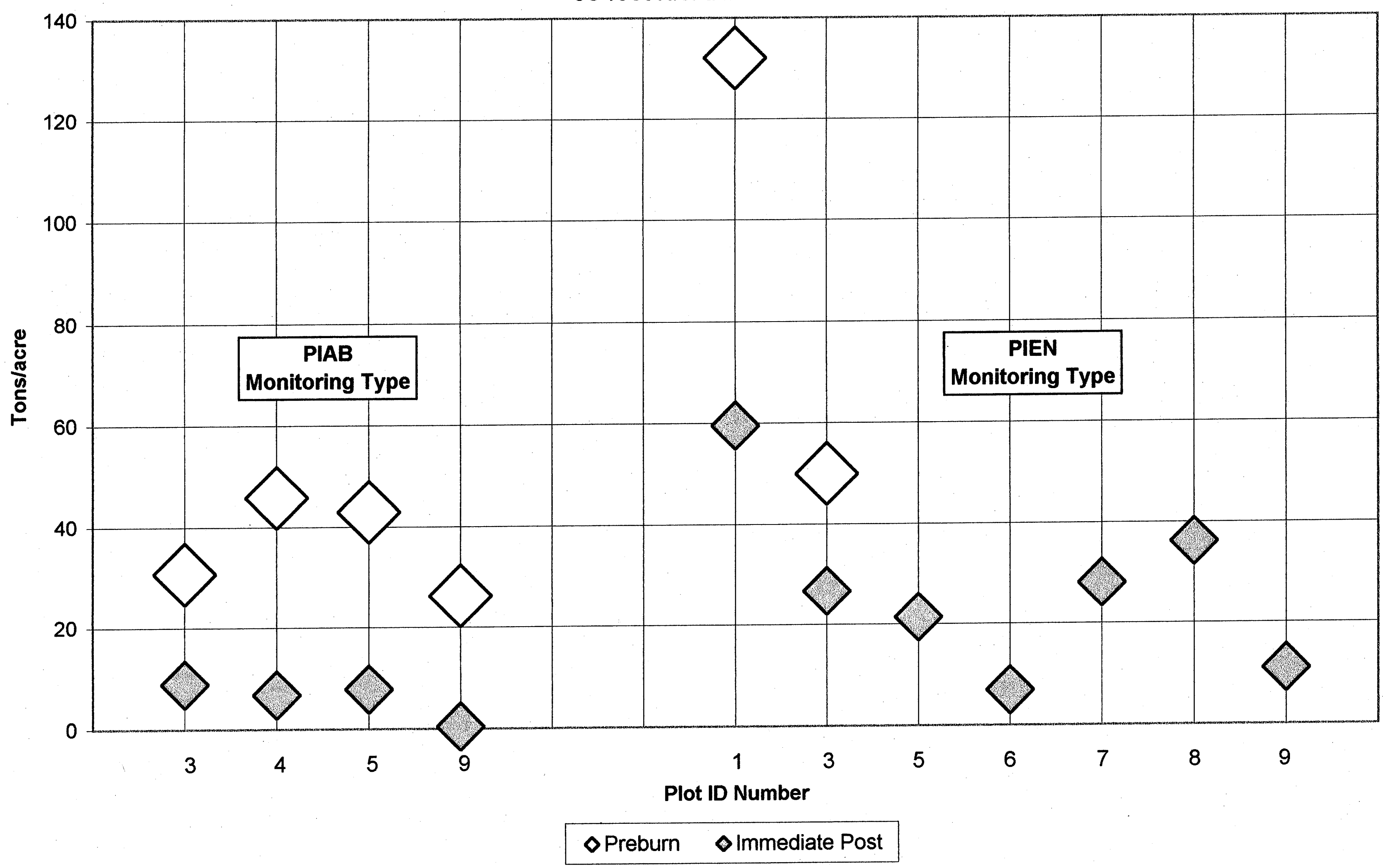


Figure 3. Total Mean Post-burn Fuel Load, PIAB & PIEN Monitoring Types
December 2000
50-foot fuels transects
n=6

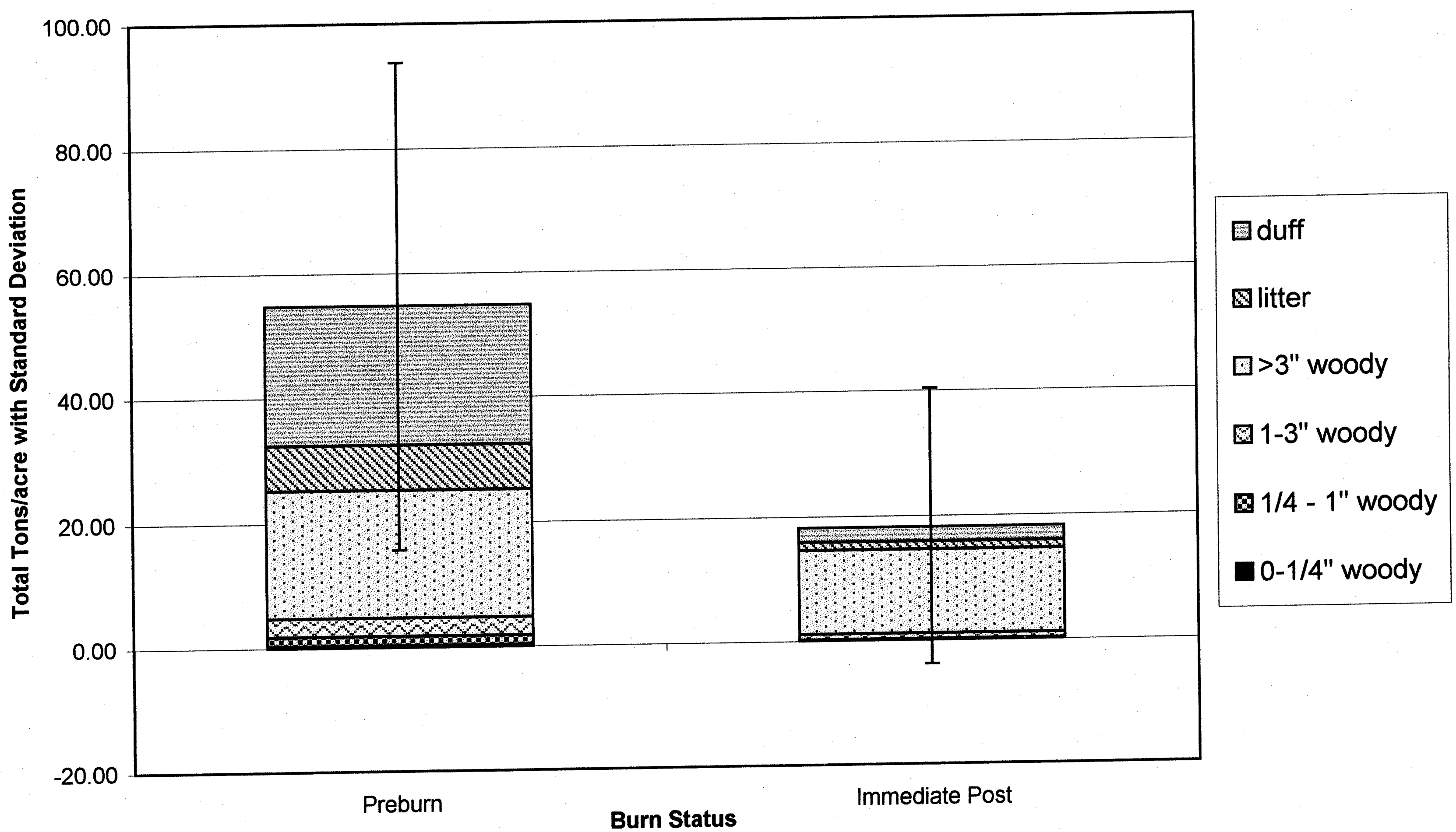


Figure 4. ***Populus tremuloides*** **Seedling Densities, by plot**
December 2000